Flight School in the Virtual Environment

Capabilities and Risks of Executing a Simulations-Based Flight Training Program

A Monograph
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Abstract

Flight School in the Virtual Environment: Capabilities and Risks of Executing a Simulations-Based Flight Training Program by MAJ Craig A. Blow, U.S. Army, 59 pages.

Based on the current unsustainable defense budget and impending reductions, the Aviation Branch must develop a plan now to prevent a deterioration of flight skills among aviators when budget reductions can potentially decrease flight training hours. Simulators' realism has improved exponentially since the 1970s due to the integration and advancement of computer technology. Army Aviation currently relies on the use of simulators to augment actual aircraft flight training in both the operating and generating forces. Analysis on the use of simulators specifically during the first two flying stages of the Initial Entry Rotary Wing (IERW) phase of Flight School XXI (FSXXI), provide leaders the insight into how to reduce aviation operating costs while maintaining or improving aviators' ability to perform in the operating force. Using current doctrine, learning theories, including transfer of training, and experiments relating simulator performance to aircraft performance, analysis determines that the current flight simulators used at FSXXI can train aviators to execute flight tasks to standard while saving costs. However, questions remain and researchers must conduct further experiments to develop empirical evidence relating directly to the capacity for simulations based primary and instruments to provide aviators of the same quality as the current training program to the operating force, and any associated risks incurred.

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Introduction

Problem

The former Chairman of the Joint Chiefs of Staff (CJCS), Admiral Michael Mullen, identified the nation's debt as a significant security risk in America's 2011 National Military Strategy.[1] In September 2011, Admiral Mullen elevated this issue to the nation's number one security threat while publicly discussing the unsustainable nature of the defense budget.[2] The new CJCS, General Martin Dempsey, made a statement during his confirmation hearing that he believes the crisis is problematic, but not the top security risk.[3] Regardless, because of the deficit, the Department of Defense (DOD) aims to cut $450 billion over the next ten years.[4] Consequently, proactive Army leaders are looking for responsible ways to reduce the Army's budget. Funding of training becomes one aspect of the budget that leaders target when faced with large budget reductions.[5] The DOD warns in the 2009 strategic training plan that "funding for training will face significant budget pressures," and training resources could go underfunded.[6]

A greater potential exists for decision makers to cut spending on Aviation flight training operations than any other category, because twenty percent of the Army's annual budget funds

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[1] Michael G. Mullen, "The National Military Strategy of the United States of America," http://www.au.af.mil/au/awc/awcgate/nms/nms.pdf (accessed October 12, 2011).

[2] Donna Miles, "Mullen: Personnel, Health Costs 'Not Sustainable'," American Forces Press Service, http://www.defense.gov/news/newsarticle.aspx?id=65418 (accessed September 22, 2011).

[3] United States Senate, Committee on Armed Services, *Nomination of GEN Martin E. Dempsey, USA, For Reappointment to the Grade of General and to be Chairman of the Joint Chiefs of Staff*, July 26, 2011, 45.

[4] Jim Garamone, "Panetta: Defense Cuts Will Be Made Strategically," American Forces Press Service, http://www.defense.gov/news/newsarticle.aspx?id=65423 (accessed September 22, 2011).

[5] *Nomination of GEN Martin E. Dempsey, USA, For Reappointment to the Grade of General and to be Chairman of the Joint Chiefs of Staff*, 14-15.

[6] William J. Lynn, "Strategic Plan for the Next Generation of Training for the Department of Defense," (Washington, D.C.: Office of the Under Secretary of Defense, 2010), 4.

aviation operations and programs, which is the most expensive category.[7] Based on the new fiscally restrained environment and the recent history of consuming a significant amount of dollars in failed programs, the commanding general of the Aviation Branch, MG Anthony Crutchfield, determined that the branch must establish a proactive “cost-culture” framework for operating within fiscally responsible budgets.[8] However, the following historical background demonstrates how budgetary cuts can reduce aviators’ capability to execute operations to the highest standards safely.

Background

The Army allocated $6.9 billion over a period of twenty-two years towards the unsuccessful RAH-66 Comanche project and finally discontinued the program in 2004. The Government Accounting Office (GAO) began to question the rationale and effects of continuing the program in 1994. They concluded that allocating a disproportionate amount of the budget towards the Comanche year after year came at the expense of modernizing the remainder of the Army’s aviation fleet.[9] This created a reduction in the operational readiness of aviation units.[10]

Nonetheless, in 1993, the Aviation Branch approved an aircraft acquisition for flight school, which saved the Army $29 million annually.[11] It acquired the civilian Bell 206B helicopter, which the Army calls the TH-67 Creek. This airframe is more economical and reliable

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[7] Randy Rotte, "Army Aviation Division Chief, G8 Update" (Presentation at the Army Aviation Center of Excellence Senior Leaders Conference, Fort Rucker, AL, February 1, 2011), 18.

[8] Anthony Crutchfield, "A Vision for the Future of Army Aviation" (Presentation at the Army Aviation Center of Excellence Senior Leaders Conference, Fort Rucker, AL, February 1, 2011), 9.

[9] U.S. General Accounting Office, "Army Aviation: Modernization Strategy Needs to Be Reassessed," (Washington, D.C.: U.S. General Accounting Office, 1994), 33.

[10] Ibid., 29-30, 33.

[11] Marti Gatlin, "TH-67 Soars to Historic Aviation Milestone," TRADOC News Service, http://www.army.mil/article/1930/TH_67_Soars_to_Historic_Aviation_Milestone/ (accessed October 18, 2011).

to operate than the UH-1H Iroquois (Huey) it replaced, and it remains the training aircraft for Flight School XXI's (FSXXI's) first phase, Initial Entry Rotary Wing (IERW), today.[12]

By terminating the Comanche program in 2004, the Aviation Branch saved another forty percent of its budget.[13] With the savings, they made considerable strides to integrate a light utility aircraft and begin research of other new aircraft. Additionally, the Aviation Branch allocated funds to prolong the life expectancy of its current fleet and modernize systems, such as counter-missile warning systems, while improving its operational readiness through associated training.[14]

In addition to the significant percentage of the Army budget devoted to the Comanche, the 1990s marked a period in history when defense budgets declined in a post-war era. This foreshadows potential issues today's Army could face due to the impending budget reduction. Upon the conclusion of Operation DESERT STORM in 1991, the Army entered a period of personnel, equipment, and training reductions, resulting in decreased operational readiness.[15] The Association of the United States Army (AUSA) provides analysis each year on the Army's annual budget. Throughout the 1990s, these analyses only superficially mentioned the financial cutbacks affecting training and readiness. However, in the FY 1999 AUSA budget analysis, strong language appeared regarding the state of the Army:

> Years of insufficient resources have left the Army in an unacceptable and precarious condition. The FY 1999 budget makes no attempt to remedy years of reduced funding. In fact,…the next seven years…[will] result in an underfunded modernization program…[that] strains soldiers [and] equipment…. The Army is fragile. We may not have a readiness crisis today, but at the current funding level, that crisis looms as a near-term reality despite the quality of our Army leaders and soldiers.[16]

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[12] Ibid.

[13] James W. Williams, *A History of Army Aviation: From Its Beginnings to the War on Terror* (New York: iUniverse, Inc., 2005), 349.

[14] Ibid., 351.

[15] Jack Spencer, "The Facts About Military Readiness," *The Heritage Foundation Backgrounder*, no. 1394 (2000): 12.

[16] Richard L. West and Charles F. Feldmayer, "Army Budget Fiscal Year 1999: An Analysis," (Arlington, VA: Association of the United States Army, Institute of Land Warfare, 1998), 75.

Military leaders sense the upcoming reductions in training, maintenance, and operations that could potentially lead to a similar crisis due to the national debt, but will try to balance cuts across the force structure to include personnel benefits.[17] Because of ongoing combat operations, however, the current CJCS, General Dempsey, understands the difficulty in making any reforms to personnel benefits at this time, potentially placing the majority of cuts on training and operations until overseas combat operations draw down significantly.[18]

A contemporary example illustrates the potential risk resulting from decreased budgets and readiness. Task Force Hawk deployed to Albania in 1999 to provide aviation support for North Atlantic Treaty Organization (NATO) operations in Kosovo. After losing an AH-64 Apache helicopter and its crew of two pilots in a fatal crash, General Richard Cody (at the time, a Brigadier General), the Task Force Commander, wrote lessons learned comments in a 1999 memorandum to General Shinseki, the Chairman of the Joint Chiefs of Staff. His statements, later discussed in a Congressional Hearing on the readiness of the AH-64 helicopter fleet, questioned the ability of pilots to fight in a high-risk environment based on the consequences of years of financial constraint.[19] Understandably, contraction in the funding of aviation training can increase risk in aviation operations.

The Aviation Branch must develop a plan now to prevent a deterioration of flight skills among aviators given the likelihood that impending budget reductions will affect funding for aviator flight training. Individual proficiency correlates directly to collective proficiency and operational effectiveness in aviation units. Leaders must protect mission readiness by developing effective and affordable training programs. The Army made a considerable advancement in flight

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[17] *Nomination of GEN Martin E. Dempsey, USA, For Reappointment to the Grade of General and to be Chairman of the Joint Chiefs of Staff*, 14-15.

[18] Ibid., 15-16.

[19] Committee on Armed Services, Military Readiness Subcommittee, *Readiness of the Army AH-64 Apache Helicopter Fleet*, First Session, July 1, 1999, 13.

simulators in 1935 with the Link trainers, but they lagged behind other services in simulator utilization until the 1960s.[20] For decades, the Army used much cheaper aircraft to operate than the other services did, so pressure to adopt the large-scale use of simulators did not emerge until the Army began purchasing more advanced aircraft like the UH-1H Iroquois. This led to procurement of the UH-1H Synthetic Flight Training System (SFTS) – one of the Army's first large scale procurements of flight simulators for enhancing aviator training while significantly reducing costs.[21] The Army continues to use flight simulators to enhance training in a safe, cost efficient environment today. This leads to the research question: Can FSXXI transition the primary flight training and instrument flight training sections of IERW to rely purely on simulations-based training without adversely affecting the operational readiness of aviation units in the operating force?

Flight Simulators

Engineers have continuously upgraded the fidelity of the simulator training experience. The simulators' realism has improved exponentially since the 1970s due to the integration of computer technology. Army Aviation currently relies on the use of simulators to augment actual aircraft flight training and conduct evaluations, and to train and evaluate responses to emergency procedures – particularly those unsafe to replicate in the actual aircraft. In the future, simulation will play an increasingly important role in accident investigations, understanding the physical and cognitive interactions between pilots and the operational environment, and other aircraft research.[22] Accordingly, as simulator technologies continue to improve and offer greater cost

[20] "Synthetic Flight Training," *U.S. Army Aviation Digest*, July 1967.

[21] Frederic H. Stubbs, "Synthetic Flight Training System," *U.S. Army Aviation Digest*, September 1972.

[22] Alfred T. Lee, *Flight Simulation: Virtual Environments in Aviation* (Aldershot, England: Ashgate Publishing Limited, 2005), ix.

benefit, instructor pilots (IPs) can increase the number of tasks they train and evaluations they conduct in the virtual environment.

With the improvement of flight simulation technology, Army Aviation has programmed an increasing amount of simulator training for pilots with two primary purposes: reducing expenses and increasing aviator proficiency. Considering future budgetary constraints, the branch chief instructed the United States Army Aviation Center of Excellence (USAACE) Directorate of Simulations (DOS) to "find more efficient and effective ways to conduct both individual and collective training using aviation simulators."[23] One option to establish the desired "cost-culture" mindset at Fort Rucker involves continuing the trend of increasing flight simulator usage, with the aim of decreasing the more expensive aircraft flight hours.

Flight school serves as a prime venue for researchers to examine the potential of transitioning to more simulator hours not only to save money, but also to increase training effectiveness, practice emergency procedures at reduced risk, and prepare the Aviation Branch for the future of flight training. Although the TH-67 airframe serves as the Army's most economical aircraft to fly, it has never undergone a reset—an overhaul on each aircraft to renew its life cycle—like the Army's other aircraft following combat operations.[24] Leaders lack specific data on how many more years the TH-67 can provide service without a reset. However, some estimate the aircraft would provide service until 2031 with a reset program.[25] Regardless, the TH-67 requires legacy repair parts that become more difficult and expensive to obtain every year.[26] If

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[23] Anthony Crutchfield, "Professionally Developing the Aviation Force," *Army Aviation*, July 31, 2011, 9-10.

[24] Michael L. Reece, interview by author, Fort Rucker, AL, December 12, 2011.

[25] John Lynch, "Future of Flight School Courses of Action," (Fort Rucker, AL: United States Army Aviation Center of Excellence, 2011), 58.

[26] Michael L. Reece, "Increasing Role of Simulation in FS XXI," *Army Aviation* 2011, 12. Even though the Aviation Branch acquired the TH-67 in 1993 for economic and performance benefits, commercial aviation is becoming increasingly digital. Consequently, the analog repair components on the TH-67 are more expensive and scarce; long-term fleet sustainment plans are becoming more expensive as well.

simulation will play an increased role, now is the time to gain greater understanding for how to accomplish it successfully.

Flight School XXI

Senior aviation leaders fully implemented FSXXI in 2007. Legacy flight school is the term used for the program prior to this time, even though an interim FSXXI program bridged the two for several years.[27] The course consists of two phases. The first phase, IERW, includes pre-flight training, primary (sometimes referred to as contact), instruments, and the basic warfighter skills sections. Although official charts depict the TH-67 supporting all IERW training, the obsolete OH-58C Kiowa serves as the training platform for the basic warfighter skills section (see Figure 1 in appendix).[28] The primary and instrument sections comprise the majority of IERW. This involves learning the fundamentals of flying and takes place over a ten-week period. Student pilots learn how to hover, react appropriately to emergencies, gain airspace awareness, and fly a traffic pattern, among other basic tasks (see Figures 2a and 2b in appendix).[29] The eight-week instrument section involves learning how to pilot the aircraft using radio navigation and relying completely on the aircraft instruments to control the aircraft (see Figures 3a and 3b in appendix).[30] The second phase consists of advanced aircraft training in one of four advanced aircraft: the AH-64D Apache, OH-58D Kiowa Warrior, CH-47D Chinook, or UH-60L/M

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[27] Kathy L. Nau, Sara K. Krondak, and Norma L Lewis, "Flight School XXI (FSXXI) Training Effectiveness Analysis (TEA)," (White Sands Missile Range, NM: TRADOC Analysis Center, 2009), chap. 1, 3.

[28] Dana Probert, email to author, January 19, 2012; United States Army Aviation Center of Excellence, "FY12 FSXXI Resourced Slide," (Fort Rucker, AL: United States Army Aviation Center of Excellence, 2011), 1.

[29] ———, "Flight Training Guide: Initial Entry Rotary Wing (IERW) Aviator (Common Core) (FSXXI) Primary," (Fort Rucker, AL: United States Army Aviation Center of Excellence, 2011), 24-75.

[30] ———, "Flight Training Guide: Initial Entry Rotary Wing (IERW) Aviator (Common Core) (FSXXI) Instrument," (Fort Rucker, AL: United States Army Aviation Center of Excellence, 2011), 20-71.

Blackhawk.[31] Once Aviation Branch assigns aviators to an advanced aircraft and trains them to fly it, they rarely train them to fly another advanced aircraft.

Aviation Branch sees the overarching purpose of FSXXI as increasing the individual operational readiness of new aviators prior to their arrival at their gaining units, where they will begin collective training. Aviation Branch makes sending quality aviators from flight school to operational units a top priority.[32] The reorganized version of flight school sends aviators to their first duty station with more hours in their advanced aircraft than the legacy version.[33] Although they still arrive at their units at Readiness Level (RL) 3, the goal of FSXXI is to train them to the proficiency level of an RL 2 aviator, a level previously achieved only after a significant amount of unit training.[34] This saves operational units money and time, allowing them to focus on training new aviators to RL 1.[35] Even though operational units now spend less money and time on new aviators, this comes at a cost, since Aviation Branch could put a student through the legacy flight school for less money than FSXXI. Part of the additional expense stems from the fact that FSXXI significantly increased the number of hours students fly in their advanced aircraft, but only moderately increased simulator hours.[36]

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[31] U.S. Army Audit Agency, "The Army's Flight School XXI Training Program," (Fort Rucker, AL 2010), 3.

[32] Lynch, "Future of Flight School Courses of Action," 6.

[33] Nau, Krondak, and Lewis, "Flight School XXI (FSXXI) Training Effectiveness Analysis (TEA)," A-1.

[34] Michael L. Wesolek, "Evaluation of the Effectiveness of Flight School XXI," (Fort Rucker, AL: U.S. Army Research Institute for the Behavioral and Social Sciences, 2007), 3; Nau, Krondak, and Lewis, "Flight School XXI (FSXXI) Training Effectiveness Analysis (TEA)," chap. 1, 4-5. RL 3 is the qualification level of aviators undergoing qualification or refresher training. They reach RL 2 once they demonstrate proficiency in all base tasks. To progress to RL 1, they must demonstrate proficiency in all the commander's specified tasks, which support the unit's mission essential task list (METL). The Aviation Branch considers RL 1 aviators fully qualified to perform their operational missions and conduct collective tasks.

[35] U.S. Army, *TC 3-04.11: Commander's Aircrew Training Program for Individual, Crew, and Collective Training* (Washington, D.C.: Department of the Army, 2009), chap. 3, 7-11.

[36] Wesolek, "Evaluation of the Effectiveness of Flight School XXI," 29.

Post-implementation studies provide cost and time comparisons between the legacy flight school and FSXXI. It costs an average of $202,398 to send a UH-60 aviator to legacy flight school, which includes both IERW and the advanced aircraft training. In comparison, it costs an average of $265,236 to send a UH-60 aviator to FSXXI – a thirty-one percent increase. When looking at the most expensive aircraft, the CH-47, the cost of flight school jumped from $342,708 (legacy) to $508, 891 (FSXXI) – a forty-eight percent increase.[37] Examining the cost for the operational unit to conduct less progression training in the advanced airframes shows FSXXI provides only minimal savings. The FSXXI UH-60 aviator saves the operational unit $20,562 as compared to the legacy flight school, for a net loss of $41,821, while the FSXXI CH-47 aviator saves the operational unit $76,218 as compared to the legacy flight school, for a net loss of $89,965.[38]

Despite the increase in financial costs, FSXXI saved operational units approximately several weeks of training time. An average UH-60 FSXXI graduate required nearly eight fewer flight hours to progress from RL 3 to RL 1–a twenty-four percent flight hour savings over legacy-trained pilots. CH-47 pilots required just four hours less, on average, to progress to RL 1–a thirteen percent decrease in required flight hours for the operational unit.[39] Despite the statistics that show the greater financial expense of FSXXI outweighs the operational units' cost savings to train an aviator to RL 1 after graduation, the operational units favor the change due to the reduced training burden placed on them when receiving FSXXI-trained aviators.[40]

The advent of FSXXI also meant the introduction of TH-67 simulators to match the training aircraft used in IERW – a significantly more advanced simulator than the previous one.

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[37] Ibid., 22.

[38] Ibid., 23.

[39] Nau, Krondak, and Lewis, "Flight School XXI (FSXXI) Training Effectiveness Analysis (TEA)," chap. 3, 1-3.

[40] Ibid., 1-6.

The eight full-motion TH-67 simulators, called Operational Flight Trainers (OFTs), provide the capability for training on all individual and crew/collective required tasks at all levels.[41] The sixteen Instrument Flight Trainers (IFTs) provide a realistic cockpit and instrument flight realism, but limits visuals to airfield approaches and takeoffs. Its capability allows for the training of all selected instrument flight tasks.[42]

The amount of programed simulator training in the initial FSXXI curriculum increased slightly from the amount received in the legacy flight school. In the primary section, the amount of simulator training rose from zero to four and a half hours, while maintaining approximately fifty hours in the aircraft; the instrument section increased from thirty simulator hours to thirty-three, with almost sixteen hours in the aircraft.[43] However, the current FY 2012 curriculum allocates just over forty-six flight hours in primary, all in the aircraft, while instruments utilizes just over fifteen aircraft hours with nearly thirty-eight hours in the simulator.[44] Thus, Aviation Branch leaders recently eliminated all simulator training for primary, the initial flying stage of IERW, while slightly increasing the percentage of simulator hours in the instrument section (see Figures 1, 4, and 5 in appendix).

By comparison, commercial fixed wing pilots have trained basic tasks in simulators for decades, along with their advanced flight training.[45] Granted, these pilots do not receive purely simulation-based initial flight training, and they already possess aeronautical ratings earned through private pilot certification in actual aircraft before learning basic tasks in commercial

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[41] Dan Farley, "FSXXI Simulator Services Contract," (Daleville, AL: CSC, FSXXI Simulation Services, 2011), 6.

[42]Ibid.

[43] U.S. Army Audit Agency, "The Army's Flight School XXI Training Program," 31.

[44] United States Army Aviation Center of Excellence, "FY12 FSXXI Resourced Slide," 1.

[45] W.A. James, "Zero Time Flight Training-American Airlines' Experience" (Presentation at the Royal Aeronautical Society Flight Simulation Group: Training Transfer--Can We Trust Flight Simulation, London, England, November, 1991), 9.5.

aircraft.[46] Other tests and experiments describe the utilization of simulators to train basic flight tasks. The current fiscal environment, the degree of technological advancement of flight simulators, and the precedent of their use within the aviation community all indicate the potential benefit of transitioning, in part or entirely, to the use of simulator training in Army Aviation FSXXI Phase I—primary and instrument sections.

Methodology

Despite its potential cost savings benefit, insufficient evidence exists to support the conclusion that FSXXI can convert to the full use of simulator training during the primary and instrument sections of IERW and still produce graduates of adequate proficiency at acceptable levels of risk to both the generating and the operating force. Qualitative data emphasizes the criticality of learning basic tasks in the real aircraft, based primarily on the professional experience of aviation leaders. Quantitative analysis demonstrates that aviators can learn individual tasks in a virtual environment and successfully transfer that learning to flight in the actual aircraft, demonstrating potential exists for increased use of simulators in FSXXI. However, a holistic analysis of all the factors that contribute to effective flight training, particularly in the specific context of FSXXI, reveals that insufficient empirical data currently exists to support the complete transformation to simulator training in the primary and instrument sections. The following analysis of the Army's doctrinal training framework, its training methodology (which includes learning theory and transfer of training (TOT) experiments), cost-benefit data, and risk, identifies the current potential for increased use of simulators, and identifies gaps which additional research must fill to enable an informed decision regarding this significant change in Army Aviation training methods.

Simulators have long played a critical role in the U.S Army's training strategy. Training and Doctrine Command (TRADOC) develops and integrates capabilities and doctrine to prepare

[46] Ibid.

the Army for success. It provides the intent and framework for how the force will conduct training and prepare for the wartime mission. The Army publishes various references that both limit and direct how Aviation Branch should utilize simulators.

The following analysis considers current training doctrine, including official training strategies, TRADOC pamphlets, field manuals, army regulations, and training circulars. These references describe the framework within which aviation simulations must operate. Army Aviation conducts the majority of simulation-based training in the Army. Aviation Branch, as the Army's simulation proponent, maintains a training strategy for the integration of live, virtual, and constructive training. This section assesses both the potential for and limitations on increased simulator use in the Army, based on the regulatory and doctrinal framework provided by TRADOC.

A review of learning models used to train pilots assists in understanding the cognitive and practical approach to translating training in a virtual environment to flying in the real environment. Studies on learning and aeronautical decision making from both military and non-military sources enable assessment of the impact of replacing all real aircraft training in the initial phases of flight school with simulation training. Both civilian and military IP schools use the Federal Aviation Administration (FAA) Aviation Instructor's Handbook, which describes the different ways student pilots learn. Assessing the learning models presented enables analysis of the effectiveness of simulators at different stages in an aviators' progression. Further, pilots can perform operational tasks based on different training methods and platforms.

A large body of work exists that assesses the translation of flight simulator training to satisfactory performance in the aircraft. Studies and reports on this topic increased in the past twenty-five years, due to the rapid improvement in simulator technology. Reports of experiments conducted to analyze the efficacy of simulation training shows that the use of flight simulators improved the translated abilities of aviators from the virtual environment to the real aircraft. They reveal that most tasks are transferable between virtual and real environments. Current research

demonstrates the relationship between the use of simulators in the virtual training environment and the ability for aviators to manipulate flight controls to standard in executing specific flight maneuvers. However, most of the studies do not focus on students flying for the first time, sometimes referred to as "ab initio" pilots in reports.[47] Studies focusing on non-ab initio pilots provide correlative data rather than direct application to the specific research question.

A cost benefit analysis augments the assessment of the viability of making a full transition to simulation. Data shows that simulators cost less to operate than real aircraft. Due to the large number of students and hours flown in FSXXI each year, potential exists to save money with increased reliability on simulators.

With regard to risk, reports compare the relationship between accidental risk and the amount and type of training received on flight simulators and flight training in general. Although few studies specifically connect accidents with simulator training, many studies demonstrate the dramatic cost of loss of life and equipment due to training shortfalls. Current research does not demonstrate adequately whether simulator training effectiveness requires a foundation of previous experience in the actual aircraft, as asserted by experienced aviators, based on their instincts and knowledge of training principles.

Limitations

Certain limitations imposed in this monograph serve the purpose of focusing the study and analysis. Although one could assess other phases of flight school for transitioning completely to simulators, this study only analyzes the feasibility of transition for the primary & instrument sections. This paper only analyzes training of active duty aviators in FSXXI; it does not address training and operational readiness of National Guard or Army Reserve aviators. However, the

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[47] Nickolas D. Macchiarella, Tim Brady, and Pamela K. Arban, "High Fidelity Flight Training Devices in the Training of Ab Initio Flight Students" (Presentation at the Digital Avionics Systems Conference, Washington, D.C., October 30-November 3, 2004).

study seeks to support generalized findings that serve as a solid foundation for studies of the feasibility of employing simulators on a broader scale in IERW training.

Army Training Framework

The Army must train soldiers, to include aviators, to execute full spectrum operations (FSO), which consists of offense, defense, and stability or civil support operations.[48] The Army focuses on balanced training to prepare its personnel for a full range of operational requirements. Understanding the basis for Army training as a whole provides the foundation for understanding aviation training. Army training conforms to the Army Force Generation (ARFORGEN) concept as the framework for all training and operations, and the Army Training Strategy outlines the goals for that training.

ARFORGEN

ARFORGEN serves as the process within which the Army trains its forces and prepares them for combat, and subdivides Army forces into three cycles based on their readiness.[49] The Army separates its forces into two categories—generating force and operating force.[50] The generating force provides initial training to forces and feeds them into the operating force—the units who conduct the wartime missions. The model arranges the progression of Army forces through three phases, which encompass the "Reset," "Train/Ready," and "Available" force pools (see Figure 6 in appendix).[51] Army training must nest within the new ARFORGEN cycle, which

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48 U.S. Army, *FM 7-0: Training Units and Developing Leaders for Full Spectrum Operations* (Washington, D.C.: Department of the Army, 2011), chap. 1, 1. The new ADP 3-0 changes the term FSO to "Decisive Action," but the Army's other doctrinal manuals still use the term "FSO" pending update in the upcoming months.

49 Daniel P. Bolger, "Army Training Strategy," ed. G-3/5/7 Office of the Deputy Chief of Staff (Washington D.C.: Department of the Army, 2011), 1.

50 U.S. Army, *AR 525-29: Army Force Generation* (Washington, D.C.: Department of the Army, 2011), 3.

51 Ibid., 1.

exists primarily to increase the number of available Brigade Combat Teams (BCTs) and supporting forces available for operational tours, while maintaining a high level of combat effectiveness.[52] Active component Combat Aviation Brigades (CABs) use the ARFORGEN model in accordance with the United States Army Forces Command (FORSCOM) doctrinal training template for training and operations.[53] The Army adopted ARFORGEN in an attempt to close the gap between the generating force and operating force by producing trained and ready forces more efficiently while supporting a sustained deployment cycle.[54]

FSXXI, part of the generating force, contributes to this goal by training aviators to RL 2, one level of proficiency higher than students that graduated from the legacy flight school.[55] A basic assumption of the ARFORGEN model contends that the generating force pool will provide capable forces to the operating force pool when required.[56] To maximize the value of the ARFORGEN model, Aviation Branch should assign recently graduated FSXXI students to units entering their Reset period, enabling them to integrate and begin progress to RL 1 as the unit prepares to enter its Train/Ready phase. This would provide newly arrived aviators time to reach RL 1 so they can participate in the small and large unit training events that take place during this Train/Ready phase.[57]

Since the viability of the ARFORGEN model relies in part on FSXXI producing highly trained aviators ready to report to their units at a logical and predictable time in their ARFORGEN cycle, Aviation Branch should avoid changes in FSXXI that jeopardize this new force management process. Therefore, IERW should not transition the primary and instrument

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[52] Ibid., 2.

[53] James. D. Thurman, "FORSCOM ARFORGEN Update" (Fort Rucker, AL, February 2, 2011), 31.

[54] Ibid., 16.

[55] Wesolek, "Evaluation of the Effectiveness of Flight School XXI," 3.

[56] *AR 525-29: Army Force Generation*, 1.

[57] Thurman, "FORSCOM ARFORGEN Update," 31, 35.

sections to purely simulation based training if this will lead to lower quality graduates or extended unpredictable graduation timelines. Thus, within the ARFORGEN cycle, the Army employs a training strategy that FSXXI must support. Any plan to increase the use of simulations must account for this requirement.

Army Training Strategy

The Army Training Strategy (ATS) describes the methodology for units to follow in preparing for their wartime mission. The "U.S. Army Training Concept: 2012-2020" complements the ATS with the future vision of training the generating force pool.[58] The ATS vision involves making Army training "realistic, tough, demanding, fast-paced, and adapted for FSO against hybrid threats within the ARFORGEN model."[59] However, the DOD "Strategic Plan for the Next Generation of Training" says the military must solve the future training problem by preparing effective and efficient training scenarios "with limited fiscal, time, material, and personnel resources."[60] Thus, the ATS identifies several objectives that guide aviation training and the use of simulators. Simulators should provide units the ability to replicate FSO training while following the tenets of an integrated training environment (ITE).[61]

The ATS directs units to execute a FSO training strategy using an "appropriate mix of Live, Virtual, Constructive and Gaming (LVCG) training enablers and an integrated architecture."[62] Although simulation for IERW does not fall squarely within the parameters of FSO training, IERW contributes to the overall training strategy by serving as the foundation for individual training within the ARFORGEN training cycle. Units should "identify innovative

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[58] Bolger, "Army Training Strategy," 6-7; U.S. Army, *TRADOC PAM 525-8-3: The U.S. Army Training Concept, 2012-2020* (Fort Monroe, VA: U.S. Army Training and Doctrine Command, 2011), 6.

[59] Bolger, "Army Training Strategy," 2.

[60] Lynn, "Strategic Plan," 3.

[61] Bolger, "Army Training Strategy," 7-8.

[62] Ibid., 11.

training methods to reduce overhead without sacrificing training quality, standards, or outcomes, [and also] adapt virtual, constructive, and gaming training capabilities wherever possible….”[63] Virtual apparatuses include training aids, devices, simulators and simulations (TADDS), which provide realistic training conditions to units.[64] Furthermore, training realism increases with the level of fidelity in the simulator. Doctrine directs units to use simulation as long as it maintains or improves soldier readiness, but it does not specify how to determine simulator effectiveness or measure the fidelity of flight simulators.

The ATS describes the ITE as an integral component of FSO training. This concept drives the Army to train and educate with more efficiency and effectiveness in support of the ARFORGEN model.[65] The Army’s strategic plan identifies this integration as a necessary component of future unit training.[66] Therefore, the Army should upgrade isolated simulators to an ITE. This links TADSS together on a network to enable collective training in the virtual environment (non-network simulators can only support individual training). However, upgrading and networking simulators increases their cost.[67] Therefore, the Army must leverage simulators to achieve realistic, demanding, and efficient training, but in a cost-effective manner.[68] The potential exists for Aviation Branch to do this in both the generating force and the operating force.

Army Aviation Training

The Aviation Branch’s doctrine nests with the ATS. In conducting training, the Army uses live, virtual, and constructive methods.[69] IERW provides the foundational training for

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[63] Ibid., 12.

[64] Ibid., 17.

[65] Ibid., 7.

[66] Lynn, "Strategic Plan," 23.

[67] U.S. Army Aviation Center of Excellence, "Aviation Live, Virtual, Constructive Training Strategy," (Fort Rucker, AL: United States Army Aviation Center of Excellence, 2008), 6-7.

[68] Bolger, "Army Training Strategy," 19.

[69] *FM 7-0: Training Units and Developing Leaders for Full Spectrum Operations*, chap. 2, 1.

aviators, which enables them to perform their wartime missions in operational units. The use of realistic simulations serves as a training aid to assist in the Army principle, "train as you will fight."[70] Therefore, the primary and instrument sections of IERW nest within the Aviation Live, Virtual, Constructive Training Strategy, and aviator training regulations.

Aviation Live, Virtual, Constructive Training Strategy:

Army Aviation conducts the majority of simulation-based training in the Army and consequently the Army selected Aviation Branch to act as the Army proponent for simulation.[71] Therefore, Aviation Branch developed its "Aviation Live, Virtual and Constructive Training Strategy," (ALVCTS) which augments the ATS with more directed focus on the Aviation Branch.[72] Although the ALVCTS includes many of the topics covered by the ATS with regard to simulations, several points create divergence. This allows for further analysis of flight simulators' usage in primary and instruments within IERW.

The ALVCTS diverges from the ATS in its specificity regarding the use of simulations to augment live training. It states the following:

> Simulators and simulations will never fully replace live training events. Aviation officers require a core baseline of live, hands-on experiences that can only be gained through realistic training on actual equipment in tough demanding conditions. The live situational experience is the basis for our success. Only when this solid foundation of live situational experience is established will we begin to fully exploit the tremendous potential of simulators and simulation.[73]

Arguably, live training events provide an important component of aviator readiness. At some point in their training cycle, they must train on the real aircraft. However, as simulation technology and methods of instruction continue to improve, simulators can replace an increasing

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[70] Ibid., chap. 2, 3.

[71] U.S. Army Aviation Center of Excellence, "Aviation Live, Virtual, Constructive Training Strategy," 1.

[72] Ibid.

[73] Ibid., 13.

number and variety of live training events. By arguing that simulators “will never fully replace live training events,” the authors of the ALVCTS assume technologies and training methodologies will never advance to the necessary level of realism, and the operating environment will always remain permissive for live training events.

The quotation above, by identifying live foundational training as mandatory for effective aviator training, helps explain the lack of simulator hours in the primary section of FSXXI. By contrast, student pilots conduct the majority of their instrument section training in the simulator, and this serves as the student’s first exposure to flying in instrument conditions.[74] Regardless, the ALVCTS plainly states that the Aviation Branch relies on live aircraft training to teach beginner students the fundamentals of flying. It relies on the logic that simulations prove effective only by building on a real experience established in the aviator’s mind with live training, which supports the conclusion that IERW can never transition completely to simulator training.

Aviation Doctrine

Several aviation doctrine publications provide the structure governing flight in both the aircraft and simulator. AR 95-1, “Flight Regulations,” provides the foundational basis for aviation policies and procedures for training and standardization.[75] The TC 3-04.11, Commander’s Aircrew Training Program (ATP), provides the basis for units’ aircrew training program, and it serves as the “keystone publication” for the aircrew training manuals (ATMs).[76] A different ATM exists for each advanced airframe in the Army, and it provides detailed guidance for simulator training. In fact, the AR 95-1 relegates authority for simulator training to these ATMs.[77] Specific to this study, two FSXXI Flight Training Guides, for primary and instruments, serve as the

[74] United States Army Aviation Center of Excellence, "Flight Training Guide: Instrument," 6.

[75] U.S. Army, *AR 95-1: Flight Regulations* (Washington, D.C.: Department of the Army, 2008), 1.

[76] *TC 3-04.11: Commander's Aircrew Training Program for Individual, Crew, and Collective Training*, vii.

[77] *AR 95-1: Flight Regulations*, 20-21.

training manuals for students flying the TH-67. Two forward-looking TRADOC pamphlets influence simulator training also.[78] Examining how these governing publications regulate the use of simulator training provides insight into the feasibility of full simulation training in this portion of IERW.

The ATP provides guidance for unit training in the operating force. It includes the Combined Arms Training Strategy, which directs commanders to "maximize the use of simulators for individual, crew, and collective training tasks."[79] Commanders must also make the training realistic and conform to requirements based on the ARFORGEN model.[80] Because ARFORGEN significantly reduces the availability of aircraft during the Reset phase due to scheduled maintenance requirements, units must rely on simulation to sustain individual training, such as RL progression and preparing aviators for collective training events.[81] The ATP states, "[v]irtual and constructive simulation training cannot replace live training. However, they can supplement, enhance, and complement live training to sustain unit proficiency…."[82] This provides another example in which Aviation doctrine both limits simulator use within the operating force, and encourages units to maximize simulator usage.

ATMs provide the governing regulations that describe different tasks and provide the minimum training time aviators should dedicate to certain aspects of training, to include the required simulator time. ATMs explain how to accomplish all flight tasks whether in the aircraft

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[78] ———, *TRADOC PAM 525-7-15: The United States Army Concept Capability Plan for Army Aviation Operations, 2015-2024* (Fort Monroe, VA: U.S. Army Training and Doctrine Command, 2008); ———, *TRADOC PAM 525-8-2 C1: The U.S. Army Learning Concept for 2015* (Fort Monroe, VA: U.S. Army Training and Doctrine Command, 2011).

[79] *TC 3-04.11: Commander's Aircrew Training Program for Individual, Crew, and Collective Training*, chap. 1, 19.

[80] Ibid., chap. 1, 7.

[81] Ibid., chap. 1, 19.

[82] Ibid., chap. 8, 4.

or in the simulator, along with the training and evaluation requirements to ensure standardization of pilots across the Army.[83]

FSXXI's Flight Training Guides for the TH-67 provides details on the conduct of simulator training in the primary and instrument sections. One manual covers primary, exclusively, and a second manual covers the instrument section. Aviation leaders dictate through these documents that students will only fly simulator hours in the instrument section of IERW (see Figures 4 and 5 in appendix).[84] Although the OFTs possess the capability for pilots to execute all primary and instrument mandated tasks, regulation prevents this from happening.[85] Despite the neglect of simulation training in primary, the Aviation Branch does accept increased reliance on simulator training within operational units. The Aviation Branch's acceptance of simulator training not just for instrument proficiency, but also for visual flight, emergency procedures, and aircrew coordination training would all seem to justify increased reliance on simulator utilization by the generating force in IERW.

FSXXI could potentially adapt some future training concepts to increase relevancy. Flight simulators could network together and integrate air traffic controllers (ATC) into the simulation to add training realism and effectiveness.[86] This design would meet the intent of the ITE by allowing students to conduct individual training in a collective environment. In the simulation network, they would see and interact with other student pilots in the class, just as they would in the live aircraft and training areas. When flying in the simulated training environment, pilots would need to make the same physical coordination within the airspace as they would in actual

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[83] ———, *TC 1-237*, *Aircrew Training Manual Utility Helicopter H-60 Series* (Washington, D.C.: Department of the Army, 2007), viii.

[84] United States Army Aviation Center of Excellence, "Flight Training Guide: Instrument," 6; ———, "Flight Training Guide: Primary," 6.

[85] Farley, "FSXXI Simulator Services Contract," 6.

[86] *TRADOC PAM 525-7-15: The United States Army Concept Capability Plan for Army Aviation Operations, 2015-2024*, 124-25.

flight, by relying on air traffic controllers to sequence aircraft into traffic patterns, instrument approaches, and collision avoidance. This level of fidelity does not currently exist with the TH-67 flight simulators.[87]

Regardless, doctrine provides a generic framework for the utilization of flight simulators to improve the operational effectiveness of individual aviators and organizational units. Doctrine provides loose boundaries in simulation use within the operating force, and it alludes to more restriction for the generating force with regard to initial pilot training. Consequently, aviation training doctrine fails to provide a clear message in the use of simulators for aviators in both the generating and operating forces. Currently, simulations cannot replace all live training, but they allow for an increased amount of training in less time and simulate situations that live scenarios cannot replicate.[88] Furthermore, analysis of various learning models (those currently used in FSXXI and other aviation learning environments) enables assessment of the cognitive and physical ability of students to learn the fundamentals of flying solely in the virtual environment.

Learning Models and Transfer of Training

The Army uses the FAA Instructor Handbook to train its IPs several learning theories for improving training in FSXXI and in operational units.[89] Both FSXXI civilian-contracted IPs and IPs from operational units attend these lessons.[90] Generally, several variables affect the ability of flight schools to produce well-trained aviators and possess relevance regarding the use of simulators in flight training. Flight schools apply a particular learning methodology that dictates how instructors use the program of instruction to teach students the required skills and tasks to graduate. The learning environment, whether virtual or real, also influences training

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[87] Maggie Amadei, interview by author, Daleville, AL, December 12, 2011.

[88] *TRADOC PAM 525-8-2 C1: The U.S. Army Learning Concept for 2015*, 24.

[89] United States Army Aviation Center of Excellence, "Aviation Instructor's Handbook: Instructing Fundamentals for Instructor Pilots," (Fort Rucker, AL: USAACE, 2009).

[90] Dana Probert, email to author, October 18, 2011.

effectiveness. Finally, the tools used for primary and instrument training must allow for the TOT into desired results (in the case of FSXXI, this variable deals with the transfer of skills learned in the TH-67 training aircraft and flight simulators so that the student can achieve advanced aircraft proficiency in a timely manner). Various tests and experiments have helped the aviation community understand these three variables and improve its training programs; however, Aviation Branch has made the least progress applying insights regarding the final variable—TOT from simulators to real aircraft—in the program of instruction for the primary and instrument phases of FSXXI. Thus, the use of learning methodology within the construct of the dictated learning environments contribute to the TOT from the simulator to the aircraft; various tests and experiments validate a positive or negative TOT.

Learning Methodology

The FAA recognizes multiple definitions of learning, which involves physical action, cognitive action, and experience to develop behavior.[91] Flight instruction should tailor the learning experience to the related activities in aviation, which are procedural, decisional, and psychomotor. Procedural activities include managing the aircraft systems and executing previously agreed upon tasks, whether dictated by SOP, regulation, or ATC direction. Decisional activities comprise the cognitive requirements of flying, such as assessing hazards, troubleshooting situations, prioritizing tasks, and assessing and responding to emergencies. Finally, psychomotor skills include manipulation of the flight controls to execute a course of action.[92] Further, researchers believe true expertise takes ten years of experience to obtain.[93]

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[91] "FAA Aviation Instructor's Handbook," ed. Federal Aviation Administration U.S. Department of Transportation, Flight Standards Service (Washington, D.C.: United States Government Printing Office, 2008), chap. 2, 2.

[92] Stanley N. Roscoe, *Aviation Psychology* (Ames, IA: The Iowa State University Press, 1980), 7, 175; Richard S. Jenson, "Pilot Judgment: Training and Evaluation," *Human Factors* 24, no. 1 (1982): 62.

[93] "FAA Aviation Instructor's Handbook," chap. 2, 27.

Regardless of the training methodology, whether using simulation or real aircraft, Aviation Branch does not intend the student to leave IERW an expert pilot. Rather, IERW provides a foundation in aviation knowledge and proficiency sufficient to prepare the student for the advanced phase of flight school and subsequently, the operational unit.

The cognitive aspect of learning is the central component in aviation training.[94] In primary and instruments, many of the basic tasks appear to focus predominately on developing psychomotor skills. Regardless, pilots rely heavily on cognitive skills such as problem solving, workload management, prioritization of tasks, communication, planning, and decision-making.[95] While cognitive learning occurs by developing "mental models," aviators learn psychomotor skills by repetition when physically manipulating the flight controls, switches, and other aircraft systems.[96]

Learning theories incorporate the concepts of learning to explain how students achieve learning outcomes. Although hundreds of learning theories exist for a multitude of applications, the focus here rests on its use within the aviation industry, as described in the FAA Instructor Handbook. From learning theory originates a problem solving methodology used to improve piloting skills. Some call this higher-level skills or higher-order thinking skills (HOTS), which students learn only in a high-quality training program. TOT occurs at multiple levels throughout the process of learning. Tests have demonstrated that flight simulators provide a means to stimulate TOT in student pilots.[97]

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[94] John E. Stewart, David M. Johnson, and William R. Howse, "Fidelity Requirements for Army Aviation Training Devices: Issues and Answers," (Fort Rucker, AL: U.S. Army Research Institute, 2008), 9-10.

[95] Lee, *Flight Simulation*: 62.

[96] Stewart, David M. Johnson, and Howse, "Fidelity Requirements," 10.

[97] Advanced Distributed Learning Research and Evaluation Team, "Designing Simulation Training to Foster Transfer: The Role of Deep Imprinting, Digital Skill Adaptability, Constructivism, and Fidelity," (Advanced Distributed Learning, 2010), 3.

The FAA and Army Aviation subscribe to several learning theories that affect pilot training. Learning theories support both civilian and military aviation training, to include FSXXI. Five foundational theories work together to explain learning in aviation—behavioral learning theory, cognitive learning theory, constructivism, experiential learning theory, and the theory of transfer. While all theories could individually provide the impetus for training specific segments of a program, instructors integrate different theories with the goal of accelerating the learning process as a whole.[98]

Behavioral learning theory posits that for a person to learn, they need an external influence to provide positive reinforcement. It relies on external conditioning to motivate and shape the person's behavior.[99] Waning in relative importance to learning, this theory still contributes to aviation training. Depending if the student executed a particular task to standard, the instructor provides either negative or positive reinforcement, which acts as the stimulus for learning.[100] The next theory contributes more to aviation learning.

Cognitive learning theory offers a rational basis for learning and recalling information. Behavioral learning differs from cognitive learning in that the former depends on the environment for learning to occur, while the latter depends on the student.[101] Cognitive theory assumes that the human memory actively organizes and processes information, and that learning builds upon prior knowledge.[102] A person acquires information, analyzes it, stores it in memory, and then recalls it when needed later.[103] Thus, the linkages between events during training are an important factor

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[98] "FAA Aviation Instructor's Handbook," chap. 2, 2.

[99] Simon Priest and Michael A. Gass, *Effective Leadership in Adventure Programming*, 2nd ed. (Champaign, IL: Human Kinetics, 2005), 14.

[100] "FAA Aviation Instructor's Handbook," chap 2, 3.

[101] Sharan B. Merriam, Rosemary S. Caffarella, and Lisa M. Baumgartner, *Learning in Adulthood: A Comprehensive Guide*, 3rd ed. (San Francisco: Pfeiffer, 2007), 285.

[102] Ibid., 284-85.

[103] Priest and Gass, *Effective Leadership in Adventure Programming*: 14.

when the aviator must recollect that data. Cognitive theory delves into how aviators think, understand situations within the operating environment, solve problems, and make decisions.

Experiential learning theory incorporates both behavioral and cognitive theories.[104] This theory harnesses the essence of the FSXXI training program.[105] David Kolb, the leading pioneer in this field, posits that people learn from actively experiencing different situations and scenarios.[106] The learning model links a four-step process together, where a person has a concrete experience, reflects upon it, and formulates an alternative course of action to improve upon the previous action. Finally, the person tests the new course of action and continues the process again.[107]

Shenan Hahn applied these learning theories to develop a model that shows student pilots can learn from experiences in simulation training. His organization, Advanced Distributed Learning, summarized his model this way:

> The trainee *experiences* the simulation…then *induces* a cognitive template of…the actual experience…with the simulator. He/she next *generalizes* the cognitive template into a schema that is imprinted into the long-term memory…. Post-training, he/she *deduces* from that schema what specific action is needed for the situation (and thus adapts the training to the current environment), *applies* that action, and *evaluates* the outcome.[108]

Simulators provide an ideal means to facilitate experiential learning by allowing aviators to gain causal understanding of the required training tasks, particularly in emergencies or instrument flight where students can learn safely in an otherwise high-risk environment.

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[104] Ibid., 15.

[105] Wesolek, "Evaluation of the Effectiveness of Flight School XXI," 7.

[106] David A. Kolb, *Experiential Learning: Experience as the Source of Learning and Development* (Englewood Cliffs, New Jersey: Prentice Hall, 1984), 6.

[107] Ibid., 21-22.

[108] Advanced Distributed Learning Research and Evaluation Team, "Designing Simulation Training to Foster Transfer," 2.

Simulator training can therefore help develop a deeply rooted cognitive understanding that aviators can apply to various situations.[109]

Constructivism, derived from the experiential learning theory, deals with students actively building knowledge and skills based on experiences and materials presented to them.[110] If given well-designed instruction in an environment that allows the student to interact effectively with the given task, the student can gain greater understanding.[111] Like cognitivists, constructivists believe that simulations and other virtual reality platforms provide more benefit to learners than training programs excluding them, because they allow students to explore tasks extensively.[112]

Higher Order Thinking Skills (HOTS) methodology enables learners to reach effective decisions and judgments. HOTS, sometimes called aeronautical decision-making (ADM), require a pilot to analyze, synthesize, and evaluate a problem to develop a solution.[113] Although primary flight training has a history of neglecting the teaching in this realm, this skill separates the effective pilot in command from the ineffective one.[114] Flight schools need to train HOTS in primary, instruments, and every subsequent training program.[115] Charles Robertson limits the scope of his FITS study to civilian aviation, but the concepts are still applicable to FSXXI. Military aviators face a multitude of complex, ill-defined problems from events that occur in

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[109] Ibid., 3.

[110] "FAA Aviation Instructor's Handbook," chap. 2, 4.

[111] Richard E. Mayer, "Designing Instruction for Constructivist Learning," in *Instructional-Design Theories and Models*, ed. Charles M. Reigeluth (Mahwah, NJ: Lawrence Erlbaum Associates, 1999), 143-44.

[112] Stephen M. Alessi and Stanley R. Trollip, *Multimedia for Learning: Methods and Development*, 3rd ed. (Boston: Allyn and Bacon, 2001), 35-37.

[113] Cynthia B. Leshin, Joellyn Pollock, and Charles M. Reigeluth, *Instructional Design Strategies and Tactics* (Englewood Cliffs, New Jersey: Educational Technology Publications, 1992), 230.

[114] Roscoe, *Aviation Psychology*: 176.

[115] Charles L. Robertson et al., "Evaluating the Effectiveness of FITS Training," (Grand Forks, ND: University of North Dakota, 2006), 3.

training to combat missions. The simulator can maximize this training to reduce risk. FSXXI teaches the basics of aircrew coordination training in IERW, which trains aeronautical decision-making.[116] Additionally, scenario-based training resides at the heart of HOTS.[117] FSXXI utilizes a number of scenarios during instrument simulator training that challenge student pilots and aid in expanding their learning.[118] More focus on this aspect of training throughout IERW with simulator use could provide valuable results.

Learning Environment

The learning environment represents the next critical variable associated with training aviators. Fidelity refers to the accuracy with which a simulator replicates flight in the real aircraft, or, put simply, the quality of the learning environment. Much debate persists with regard to the required fidelity for optimizing training. Moreover, how the pilot perceives the fidelity matters most in the simulation, not how accurately the cockpit environment portrays the real aircraft.[119] Flight simulators do not have to provide a replica of all human sensory stimuli to provide a quality training experience. They must only provide an accurate replication of the environment specifically required to learn the applicable tasks.[120]

The simulator's fidelity consists of physical, cognitive, and emotional characteristics.[121] This supports the different ways student pilots learn. Physical realism in the simulator equates to

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[116] United States Army Aviation Center of Excellence, "Flight Training Guide: Primary," 77-78.

———, "Flight Training Guide: Instrument," 62-64.

[117] Robertson et al., "Evaluating the Effectiveness of FITS Training," 4.

[118] Amadei, interview.

[119] Lee, *Flight Simulation*: 65.

[120] Ibid., 62.

[121] Ibid., 65.

Albert Rizzo et al., "Human Emotional State and its Relevance for Military VR Training" (Presentation at the 11th International Conference on Human Computer Interaction, Las Vegas, NV, July, 2005), 1.

physical aspects of the cockpit, to include controls, switches, instruments, and displays.[122] Simulator effectiveness also relies heavily on the cognitive fidelity achieved, which results from the creation of a realistic information environment that challenges the pilot's cognitive domain.[123] The information environment includes all the systems that provide the aircrew with data it must process and react to, including aircraft instruments, fellow crewmembers, ATC, and other aircraft operating in close (virtual) proximity. Emotional fidelity often results in more realistic training in the simulator than in the aircraft due to the simulator's unique capability to facilitate emergency procedures training. Instructor pilots simply cannot safely replicate many emergencies in the aircraft, but they can replicate any emergency in the simulator, where a crash is a learning event – rather than a tragedy – that often elicits a highly emotional response from the aviator.[124]

A high-fidelity simulator acts, looks, and feels like the real aircraft. The Army considers all its advanced aircraft simulators, including the TH-67 OFT, high-fidelity simulators, although they actually contain varying levels of the fidelity described above. The IFT simulators used in the instrument section possess a realistic cockpit, but have limited visuals to show only the airport runway when breaking out of the clouds on an approach to the ground.[125] Thus, the IFT provides less fidelity than the OFT, but enough to train the required instrument flight tasks, particularly since instrument flight often takes place in a limited visibility environment similar to that experienced in the IFT. A low-fidelity simulator, such as a static procedural trainer, or those replicated by various forms of flight simulator software – many of which serve entertainment rather than educational purposes – provides minimal realism. Nevertheless, research indicates student pilots do not require many of the sensory cues provided by high-fidelity simulators, and can benefit equally when only provided the specific cues associated with the task they are

[122] Lee, *Flight Simulation*: 65.

[123] Ibid., 68, 70-71.

[124] Rizzo et al., "Human Emotional State and its Relevance for Military VR Training," 1.

[125] Farley, "FSXXI Simulator Services Contract," 6.

learning.[126] Beginner aviators can typically learn many required tasks in a cost effective, low fidelity simulator, under a well-designed, proficiency-based training program.[127] These programs succeed by using simulators when they result in effective TOT to the real aircraft.[128]

Transfer of Training

Positive and negative TOT describes the simulator's level of effectiveness. When the simulator exhibits positive TOT, the simulator trains the specified task to standard in less time than it would take in the real aircraft. Conversely, negative TOT occurs when either the simulator cannot train the given task to standard, or in attempting the training, the pilot develops improper methodology and must relearn and retrain the task in the real aircraft, thus costing more training time than teaching the task in the aircraft from the beginning.[129] The theory provides understanding for how simulator training can produce successful aviators in live aircraft.

A complex process with many variables, TOT allows student pilots to build on each task they learn in FSXXI, and apply it to required situations in future training and combat operations.[130] For example, in training emergency procedures (EPs), memorization of a set of required steps does not lead to TOT by itself.[131] TOT requires some form of practical application. Utilizing simulators in primary and instruments in flight school would allow instructors to teach the student the physical steps necessary to perform an emergency procedure first, and then transfer that training by executing that emergency procedure in the actual aircraft. The presence

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[126] Stewart, David M. Johnson, and Howse, "Fidelity Requirements," 8.

[127] Ibid., 7-8; Alessi and Trollip, *Multimedia for Learning*: 234.

[128] Ruth Colvin Clark, *Building Expertise: Cognitive Methods for Training and Performance Improvement*, 3rd ed. (San Fransisco: Pfeiffer, 2008), 255-56.

[129] Esa M. Rantanen and Donald A. Talleur, "Incremental Transfer and Cost Effectiveness of Ground-Based Flight Trainers in University Aviation Programs" (Presentation at the Human Factors and Ergonomics Society 49th Annual Meeting, Orlando, FL, September, 2005), 1.

[130] Robert E. Haskell, *Transfer of Learning: Cognition, Instruction, and Reasoning* (San Diego: Academic Press, 2001), 29-30.

[131] Ibid., 36.

of a properly trained IP mitigates the risk of suboptimal TOT by providing a controlled environment in which to execute the training in the simulator and then in the real aircraft.

Transfer of learning, a closely associated factor that affects TOT, occurs when a person takes the learning from one activity and translates it into performance in a different environment.[132] A positive transfer of learning occurs when the student trains under a range of scenarios.[133] Simulators serve as an efficient and flexible means that enhance the transfer of learning to the real aircraft and differing environments. Transfer of learning actually represents a more important component of effective training than technology.[134] If executing a particular task in the simulator does not sufficiently replicate execution of the same task in the aircraft, then simulator training may hinder learning. Instructors should make positive transfer a primary objective for all training events, helping students understand how to accomplish tasks in different situations after learning the fundamental task.[135]

In ensuring transfer of learning, IPs must account for the important principle of primacy. This principle holds that whatever student pilots learn first imprints on their memory, creating habits that prove difficult to correct if necessary due to a flaw in the student's initial training.[136] This principle heightens the need for students to train and develop fundamentally sound habits from the beginning of their flight training. Students in IERW should avoid training any tasks in simulators if they create a negative learning transfer. Developers of the FSXXI curriculum state that the primacy principle drives their logic for removing simulation training from the primary

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[132] Alessi and Trollip, *Multimedia for Learning*: 29.

[133] "FAA Aviation Instructor's Handbook," chap. 2, 36.

[134] Haskell, *Transfer of Learning*: 7.

[135] "FAA Aviation Instructor's Handbook," chap. 2, 36.

[136] Ibid., 2-37.

flight training section.[137] However, research demonstrates the effectiveness of simulators in training students in all phases of learning.[138]

Simulator developers often neglect consideration of how the student pilot learns.[139] FSXXI, and Army Aviation as a whole, contains IPs who exhibit a strong bias against fully embracing the mandated flight simulation training for various reasons.[140] Most base this bias on a view of the simulator as an economical training platform that lacks the training capability of the real aircraft. Leaders in the simulation industry often hold their own bias, driven by economic motivations. The desire to sell more simulators causes many in the industry to attempt to produce the most realistic, highest fidelity product possible, which results in the rising cost of simulators.[141] To meet the commander's intent of maintaining the quality of aviator produced at FSXXI, leaders assume that the most realistic simulation provides the best training.[142] However, experts in various parts of the aviation industry fail to understand that a more effective training device, measured in terms of both well-trained pilots and reduced cost, relies as much on a well-crafted training program as expensive (and often unnecessary) technology.[143] "We must abandon the notion that simulation equals training and the simplistic view that higher fidelity means better training. . . . [T]hese views are not correct and will prevent us from considering and developing

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[137] Dana Probert, interview by author, Fort Rucker, AL, December 13, 2011.

[138] Alessi and Trollip, *Multimedia for Learning*: 7, 11.

[139] Eduardo Salas, Clint A. Bowers, and Lori Rhodenizer, "It Is Not How Much You Have But How You Use It: Toward a Rational Use of Simulation to Support Aviation Training," *International Journal of Aviation Psychology* 8, no. 3 (2005): 200.

[140] Kevin Hottell, interview by author, Fort Rucker, AL, December 12, 2011.

[141] Stewart, David M. Johnson, and Howse, "Fidelity Requirements," 3.

[142] Stewart, interview.

[143] Salas, Bowers, and Rhodenizer, "It Is Not How Much You Have But How You Use It," 200; Stewart, David M. Johnson, and Howse, "Fidelity Requirements," 6.

more effective strategies for training aviators."[144] Studies reveal how transfer of training and learning manifests itself in practical application from simulator to aircraft.

Tests, Experiments

Historically, experiments show that simulators typically achieve positive TOT. U.S. Navy flight school experiments in 1943 and 1945 showed that students receiving more simulator time than the control group, who received little or no simulator training, accomplished the initial flight school milestones, such as time to solo flight, at a faster rate and had less flight failures. However, in both cases the experimental and control groups reached parity in performance as actual aircraft training progressed.[145] In 1949, the University of Illinois and Link Aviation conducted an experiment for the primary phase of flight training. Conclusions indicated the experimental group using flight simulators learned the required tasks in about half as much time as the control group and committed fewer errors.[146] Two 1968 Army flight school experiments produced results supporting the use of simulation. The first, for the primary stage of flight school, showed that the experiment groups using just less than ten hours of simulator time experienced far fewer failures, and they required fewer training hours to prepare for their first solo flight.[147] Finally, a 1971-72 basic instruments experiment showed that students trained exclusively in the simulator successfully accomplished all required tasks in fifty-five percent fewer flight hours than the group trained exclusively in the aircraft.[148] These experiments demonstrate simulator training has achieved excellent results training ab initio students in both primary and instruments in

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[144] Salas, Bowers, and Rhodenizer, "It Is Not How Much You Have But How You Use It," 205.

[145] Gene S. Micheli, "Analysis of the Transfer of Training, Substitution, and Fidelity of Simulation of Transfer Equipment," (Orlando, FL: Training Analysis and Evaluation Group, Naval Training Equipment Center, 1972), 25.

[146] Ibid., 26.

[147] Ibid., 30.

[148] Ibid., 34.

various civilian and military flight schools, even with early generation flight simulators possessing low fidelity.

A more recent study conducted by Stewart, Dohme, and Nullmeyer, based on Dohme's experiments from the 1990s, revealed ab initio students who received simulation-based training alone reached proficiency in less time than the group who received none.[149] Few studies show no evidence of TOT from flight simulators to real aircraft; they predominately demonstrate varying degrees of positive transfer.[150] One negative case, a 2005 computer-based simulation conducted by Jan Roessingh showed no TOT, but even this test demonstrated various advantages that other professionals argued did not provide a measurable effect or fell outside the stated research objectives.[151] For example, after the computer-based training, students understood the concepts of the maneuvers better than students who only received classroom training, and they required less pre-flight briefing time from the instructors.[152] The required time for instructors decreased by fifteen minutes per brief, which provides considerable timesaving that could shift to increasing training time elsewhere.

The Army Aviation Center of Excellence, led by the Department of Simulation (DOS), conducted a test with CH-47 pilots who possessed differing experience levels. First, the advanced pilots who flew with operational units and returned to Fort Rucker for the Maintenance Test Pilot Course (MTPC) conducted one experiment, while new aviators who recently finished IERW and were attending phase two of FSXXI with the CH-47 conducted a second experiment. The MTPC students trained under nearly 100 percent simulator conditions, while the FSXXI students trained

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[149] John E. Stewart, John A. Dohme, and Robert T. Nullmeyer, "U.S. Army Initial Entry Rotary-Wing Transfer of Training Research," *The International Journal of Aviation Psychology* 12, no. 4 (2002): 371.

[150] Stewart, David M. Johnson, and Howse, "Fidelity Requirements," 2.

[151] Jan J. Roessingh, "Transfer of Manual Flying Skills from PC-Based Simulation to Actual Flight--A Comparison of In-Flight Measured Data and Instructor Ratings," in *NATO Research & Technology Organisation, RTO-MP-MSG-035* (2005), chap. 14, 18.

[152] Ibid.

under seventy-five percent simulator conditions. Despite several significant fidelity issues, the tests resulted in successful accomplishment of tasks and demonstrated the simulator training reduced total aircraft flight hour requirements.[153] Because the simulator possesses anomalies with regard to several maneuvers, such as slope landings and taxiing, instructors had to retrain students in the method of executing certain tasks once in the real aircraft.[154] However, because of this and other factors, the CH-47 FSXXI simulator study unintentionally found an improved sequence of training tasks and a method for incorporating specific training devices to overcome these issues. In addition, IPs developed improved techniques to conduct simulator training, which improved fidelity and the quality of training.[155] Developers of the FSXXI Program of Instruction (POI) should analyze how to integrate these findings into their program.

Several years ago, Colonel Anthony Krogh served as the DOS chief at Fort Rucker, AL, and wanted to get a firsthand experience of the pilots' simulator training. As a functional area 57 Simulation Operations officer, he had never flown an aircraft or operated a flight simulator before. What began as an inquiry into a "day in the life" of a student aviator, evolved into an anecdotal illustration of the possibilities of simulator training. Over the course of almost two years, Colonel Krogh progressed through primary and instrument training, solely in the new TH-67 FSXXI OFT, and attended all flight academic classes the student pilots received. Working with student IPs attending the IP Course (IPC), he passed check rides in the simulator after the primary, instrument, and basic warfighter skills sections of FSXXI. When the DOS realized the implications of his success, they pushed the envelope further, gaining approval for Colonel Krogh to attend UH-60 advanced aircraft training – or Phase Two of FSXXI. Upon completing the

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[153] "CH47D Simulation Test: MTPC Class 11-002 & FSXXI Class 11-919 Command Outbrief," (Fort Rucker, AL: U.S. Army Aviation Center of Excellence, 2011), 4.

[154] Ibid., 11.

[155] "CH47D FSXXI Class 11-919 Simulation Test Data Rollup V2," (Fort Rucker, AL: U.S. Army Aviation Center of Excellence, 2011), 14.

qualification course in the UH-60 full motion simulator and passing the final check ride, he climbed into the front seat of an aircraft for the first time in his life—a UH-60 Blackhawk. A student pilot-in-command occupied the other front seat, and the student IP's instructor, a senior IP, graded the student IP from the back seat as she administered a full-scale official check ride of Colonel Krogh, the student pilot. Colonel Krogh executed all tasks to standard and passed the AQC-level check ride in his first flight in an actual UH-60 aircraft. The student IP also passed her exam, successfully instructing and grading the check ride, thus ensuring Colonel Krogh completed all maneuvers to standard.[156] This anecdotal experiment displays the capability simulators possess to serve as the tools for teaching student pilots the physical ability to fly a helicopter and execute a series of tasks to standard. However, it lacks any formal assessment of the risk involved in Colonel Krogh's training, making it impossible to evaluate the risk of attempting such training in a FSXXI primary and instrument setting.

IERW simulator experiments in the 1990's showed that simulation-augmented IERW training would provide advantages in training effectiveness and efficiency.[157] The authors made recommendations to conduct further research, which would progress the study and expand the relevant data available to make decisions in changing the IERW curriculum, but this project lost traction and Aviation Branch never completed it.[158] Regardless, the data showed that the simulator could effectively train basic flight control skills. Students who trained in the flight simulator took less time to reach proficiency in the actual aircraft on most tasks.[159]

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[156] Anthony Krogh, interview by author, Fort Leavenworth, KS, December 6, 2011.

[157] Stewart, John A. Dohme, and Nullmeyer, "U.S. Army IERW Transfer of Training," 374.

[158] Ibid.

[159] Ibid., 373.

The Army Research Institute (ARI) conducts research and analysis on training as it strives to enhance individual and group performance.[160] Learning improved methods of decision-making and execution leads to successful accomplishment of operational requirements.[161] Although ARI finds itself among many other research and development organizations in the military to experience funding cuts, the Fort Rucker ARI could further simulation-based studies with additional resources, just as they have done in the past.[162] ARI has not executed extensive empirical research comparing alternative learning models within FSXXI, although they recognize this study needs accomplished.[163]

Cost-Benefit Analysis

Aviation provides the Army with tremendous mobility, allowing for extended operational reach and operations in depth of the battlefield, which subsequently generates a high price tag. Consequently, cost-benefit analysis must accompany everything involved with it to achieve efficiencies.[164] Logically, FSXXI should adopt simulation only if it trains aviators as effectively as or more effectively than the real aircraft, and, if the simulators cost either the same as or less than the costs to operate the real aircraft.[165]

The TH-67 simulator to real aircraft cost comparison does not provide a fully compatible assessment. Officials at FSXXI account for the full expense per aircraft for each individual

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[160] U.S. Army Research Institute, "About ARI, Mission," http://www.hqda.army.mil/ari/about/mission.shtml (accessed January 14, 2012).

[161] Ibid.

[162] John E. Stewart, interview by author, Fort Rucker, AL, December 13, 2011. Fort Rucker ARI once had a dedicated test facility with several types of simulators on which to conduct these experiments. However, officials removed these simulators and slashed the staff down from seventeen personnel to just one PhD. Fort Rucker ARI by no means presents the only example of decreased research and development programs across the U.S. armed forces.

[163] John E. Stewart, e-mail to author, November 1, 2011.

[164] Thurman, "FORSCOM ARFORGEN Update," 50-51.

[165] Jesse Orlansky et al., "The Value of Simulation for Training," (Alexandria, VA: Institute for Defense Analyses, 1994), III-2.

airframe, while they track the simulator expense as one total expense because it resides under one contract. This contract encompasses all simulators of every airframe.[166] The TH-67 portion of the simulator contract consumes less than half of the overall expense.[167] The live TH-67 costs $1,041 per hour, which encompasses all expenses, including fuel, parts, maintenance, and contractor support.[168] The complete simulator contract for all FSXXI equipment, use, maintenance, and contractor support costs $466 per hour, well under half of the expense of the Army's cheapest airframe.[169]

Based on one assessment, the Aviation Branch would need to purchase an additional eight TH-67 flight simulators (either OFTs or IFTs), to accomplish 100 percent facilitation of the instrument section of IERW in the simulator.[170] No researchers have provided detailed assessments on the requirements or costs to move to a fully simulator-based primary training program in IERW. However, one rough estimate projects that to build another wing on Warrior Hall, where the pilots conduct simulator training, and add an additional twenty-four to thirty-two OFT simulators to facilitate primary training, the overall simulator contract would not rise above $1000 per hour. This estimate, which encompasses not only the TH-67 simulators, but also all other airframes' simulators, remains below the operational cost per hour of the real TH-67.

To put this cost in perspective of the Army's combat aircraft highlights the reason the Army transitioned to the TH-67 helicopter in the first place. At $1,041 per hour, the TH-67 is by far the cheapest airframe the Army operates, more than fifty percent less than the OH-58D, and far less than the other airframes. The UH-60 costs about $3,000 per hour to operate, depending on model, the AH-64D costs $4,862 per hour, while the CH-47D and F-models cost $7,519 and

[166] Hottell, interview.

[167] Kevin Hottell, phone conversation with author, January 19, 2012.

[168] Kevin Hottell, "Simulator White Space: The Realm of the Possible," (Fort Rucker, AL: Army Aviation Center of Excellence Department of Simulation, 2011), 3.

[169] Hottell, interview.

[170] Lynch, "Future of Flight School Courses of Action," 35.

$10,804 per hour, respectively.[171] Because of this wide gap in cost per airframes, much of the current focus in the DOS rests with moving more combat aircraft training to simulators, rather than TH-67 primary and instrument training.[172] The DOS is currently conducting tests on the UH-60 FSXXI classes and Maintenance Test Pilot Course (MTPC), much like the CH-47 experiments conducted last year.[173] Furthermore, FSXXI can benefit financially by converting more training from all airframes to a simulator-based program.

Risk

For leaders to implement increased simulator training in FSXXI, it must not result in non-proficient aviators. It must not create a safety hazard to the lives of aviators and crewmembers, or contribute to the destruction of property. Numerous positive training implications exist with respect to simulator-based training. As discussed in the TOT and experiments sections, experiments and tests demonstrate the accomplishment of training tasks according to prescribed standards in the simulator. With regard to administering instruction, IPs can immediately freeze training to address specific objectives or learning points, and review video tape during the debrief period to emphasize critical learning objectives.[174] Other benefits of simulation include the ability to conduct more iterations of each maneuver in a condensed time.[175] However, many officials see detrimental risk to transitioning to a fully simulator-based primary and instrument training program.

When presenting courses of action to MG Crutchfield on the future of FSXXI last year, the 110th Aviation Brigade (the brigade responsible for the execution of FSXXI) eliminated the

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[171] Hottell, "Simulator White Space," 3.

[172] Hottell, interview; "CH47D FSXXI Class 11-919 Simulation Test Data Rollup V2."; "CH47D Simulation Test: MTPC Class 11-002 & FSXXI Class 11-919 Command Outbrief."

[173] Hottell, interview.

[174] Rob Ness, email to author, August 31, 2011; Amadei, interview.

[175] Stewart, John A. Dohme, and Nullmeyer, "U.S. Army IERW Transfer of Training," 372.

COA advocating the conversion to 100 percent simulator-based instrument training because they viewed it as “high risk to [the] quality of [the] common core IERW student,” among other factors.[176] When eliminating the four and one half simulator hours from the primary section and moving it to the instrument section of IERW in 2010, the 110th Aviation Brigade touted this course of action as representative of the “best aviator” training solution.[177] Although this stance could be true, nevertheless, the recommendation lacked any scientifically based research analysis or testing to support the subjective endorsement.

Senior officers understand the capability simulators bring to the training environment to help reduce aviation operational risk. Officials agreed in a General Officer’s Steering Committee Meeting on the mandate to decrease accidents with the use of improved training and simulator usage.[178] The concern remains that the cost of using only simulations in FSXXI primary and instruments could lead to the output of unsafe aviators, creating a catastrophic loss of life and equipment if executed too quickly. Improper training techniques and methodology could lead to an increase in accidental risk if conducted improperly, but decrease risk if conducted at the appropriate time and manner. Although the U.S. Army National Simulations Director believes FSXXI could transition completely to simulation-based primary and instruments, he considers the risk as too great to execute the change quickly.[179] Preventing accidents and understanding the relationship between simulator usage and safety remain pointed topics in the aviation community.

In FY 2010, one issue common to more than a third of the fatal accidents was failure in crew coordination.[180] Human factors, which encompass crew coordination, account for

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[176] Lynch, "Future of Flight School Courses of Action," 39.

[177] Russ Stinger, "110th Aviation Brigade IERW POI Review Working Group COA Presentation to CG," (Fort Rucker, AL: 110th Aviation Brigade, 2010), 8.

[178] U.S. Army Aviation Center of Excellence, "Aviation Live, Virtual, Constructive Training Strategy," 1, Enclosure 1.

[179] Krogh, interview.

[180] Thurman, "FORSCOM ARFORGEN Update," 57.

approximately eighty percent of all aviation accidents. This can consist of a single decision a pilot makes, neglect to take action in a situation, or a chain of events for which the pilot is responsible.[181] By ensuring IPs teach and practice crew coordination elements during the basic tasks, the tendency increases for the habit to transfer over to difficult tasks, especially during critical periods in flight.[182] This reinforces the notion that FSXXI must focus on the instruction of crew coordination aspects using all means available, especially simulation.

One recent study conducted by the Center for Naval Analyses (CNA) shows statistics and causes for aviation accidents.[183] It also reveals that Marine Aviation began focusing their simulator usage with the goal of mitigating risk.[184] Although the study attempted to assess overall capabilities of pilots and mishaps in relation to their simulator time accrued, it could not assess the direct relation between accidents and the pilot's simulator time.[185] Rather, based on the data available, the study revealed the occurrences of accidents in relation to pilots' total flight hour experience, which includes simulator flight time.[186] The population of junior pilots with fewer than 400 total flight hours and fewer than ten flight hours in the past thirty days committed more mishaps than any other group.[187] In a flight hour comparison, at the conclusion of the Army's FSXXI, student aviators have flown from 207 to 278 total hours.[188] Regardless, the CNA

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[181] "FAA Aviation Instructor's Handbook," 8-14.

[182] Thurman, "FORSCOM ARFORGEN Update," 57.

[183] Sarah A. Stevenson, V. Reid Smith, and William D. Brobst, "Evolving Role of Simulator Time in Defining Pilot Experience Levels: F-35B Flight/Simulator Relationship," (Alexandria, VA: CNA Analysis and Solutions, 2011), 45.

[184] Ibid., 3.

[185] Ibid., 1, 5, 39.

[186] Ibid., 55.

[187] Ibid., 47.

[188] United States Army Aviation Center of Excellence, "FY12 FSXXI Resourced Slide," 1. Total flight hours vary for each student, primarily based on which advanced airframe the student flies.

recognizes the lack of data relating accidents to simulator training, and declares that future study must elaborate on how simulator usage will affect flight safety.[189]

One example within the Army surrounds the OH-58D(R) Full Authority Digital Electronic Control (FADEC), which controls the performance of the aircraft engine. Investigators attributed a February 2010 accident to a FADEC malfunction and subsequent failure of the pilots to react properly to the emergency procedure, among many other circumstances. Following this accident, the United States Army Safety Center recommended implementation of several risk mitigation measures.[190] Headquarters, Department of the Army Military Operations (DAMO), implemented several recommendations, one of which directed all OH-58D(R) aviators go to Fort Rucker to conduct three hours annually of FADEC emergency procedure training in the simulator facility to train the updated procedure.[191] After this simulator-training requirement took effect, along with the other mitigation measures, no other FADEC-related accidents have occurred in the OH-58D.[192]

The training and accident reduction benefits of simulators provide support for the use of simulator training in IERW. However, serious risks could remain on a holistic perspective of the quality of aviator produced based on a complete transformation of primary and instruments to simulators. Without existing empirical evidence on the quality of aviator produced in a simulator-focused program, Aviation Branch leaders have based decisions on the amount of simulator training to use in primary and instruments on subjective thought processes primarily based on their knowledge of learning theory, especially primacy, and professional experiences.

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[189] Stevenson, Smith, and Brobst, "Evolving Role of Simulator Time in Defining Pilot Experience Levels," 55.

[190] William Peaster, "Finding and Recommendation for a Class A OH-58D(R) Accident," (Fort Rucker, AL: United States Army Combat Readiness/Safety Center, 2010), 2.

[191] Stephen Burns, "HQDA Guidance / OH-58D FADEC Manual Throttle Operations," (Washington, D.C.: Department of the Army, G3, 2010), 2. The Army Aviation's DOS owns the only OH-58D simulators in the Army, located at Fort Rucker, AL.

[192] Hottell, interview.

Conclusion

The security threat promulgated by the nation’s excessive debt produced an environment where the U.S. military faces an impending budget reduction. Because Army Aviation holds the largest funding requirements for aviation operations, leaders should prudently anticipate reduced funding. The responsibility of the Aviation Branch, however, remains to train and equip the best aviators to serve in the operational force, which begins by receiving the best aviation training possible at FSXXI. With the advancement of simulation technology and learning theory, the virtual environment possesses the capability to play a larger role in the training of flight students.

The Army training framework provides doctrine that establishes a foundation for managing aviation training within the ARFORGEN construct, affecting both the generating and operating forces. Doctrine shapes the use of simulation by providing loose direction and boundaries. Doctrine states that simulators will never fully replace live training events, and student pilots require live experience to provide foundational understanding to aviation before they can access the potential training value of simulations. Aside from the FSXXI POI, training publications acknowledge the potential of flight simulators to improve the quality of aviators, but the publications fail to provide detailed guidance or mandates in simulator use.

Even though simulation technology advanced rapidly, the methods of training in the simulator has lagged significantly. Learning theory provides the framework for how student aviators learn. The fidelity of a simulator describes the learning environment the pilot must submerse into, while tests and experiments reveal that simulators predominately train the required tasks successfully. Low fidelity simulators can produce quality training if used correctly, but the current OFT TH-67 simulators provide enough fidelity to train all required primary and instrument tasks. However, tests and experiments do not show how they could affect an entire initial flight-training program or second and third order consequences leading to performance in operational units. Flight instructors as a whole do not utilize the simulator to its fullest capability,

and in many cases, lack the knowledge and training program geared towards maximizing the learning in student pilots.

The cost benefit analysis shows that FSXXI can reduce financial costs significantly by moving to a purely simulation based training program in primary and instruments, but save less money focused on the TH-67 than the advanced airframes. Although, simulators have proven themselves as effective at training individual flight tasks, the resulting product as a whole from purely simulation-based training remains unknown and subjectively considered high risk. Simulators have proven effective tools in helping mitigate risk, but quantitative data lacks in specifically attributing the presence of simulator training to the absence of accidents.

Despite its potential cost saving benefit, no evidence exists that converting to the full use of simulator training during the primary and instrument sections of IERW would result in graduates serving in the operating force with the same or increased levels of proficiency. Army and Army Aviation doctrine encourages the use of simulations, but imposes boundaries from utilizing simulators fully in place of live training events. When training programs maximize learning theory principles that correlate with initial flight training, transfer of training occurs from flight simulators to the real aircraft. However, without further research targeted at this specific problem in the context of the primary and instrument sections within FSXXI, making such radical change could create risk that outweighs the benefits.

Implications and Recommended Future Study

The Army's FSXXI provides the best rotary wing aviators in the world. Army Aviation should not make any changes to a program that reduces the proficiency of the graduates assigned to the operational force. Analysts know the data on the financial cost of training and can predict future simulator expenses in relation to the cost per hour of individual airframes. Thus, future studies must provide empirical data regarding the quality of aviator produced after completing various levels of simulator and real aircraft training. First, however, the Army should utilize the

ARI to develop the existing learning theory research as applied to the use of simulators in FSXXI. If this empirical data produces positive results, the Aviation Branch should base future POI studies on an intentionally tailored training program that focuses on learning method efficiencies and maximizing the role of simulators. The goal of increasing simulator usage should provide higher quality aviators at a reduced price. By updating doctrine and training programs, the Aviation Branch can provide increased benefits at less cost.

Doctrinal implications of utilizing an increased amount of simulator training involve updating publications to direct the appropriate quality of simulator training necessary. Based on current and future research of simulator training, doctrine should acknowledge the strengths and weaknesses of various virtual devices. It should provide the proper level of emphasis on the training programs that use the devices, not on the devices themselves, which serve merely as training tools.

The Army needs not invest in simulators of higher fidelity for FSXXI, as the current OFTs can allow for the execution of a high-quality training program. The remaining questions rest in the realm of instruction and training methodologies. If the ARI research produces positive data on the use of utilizing improved methodologies in flight instruction, then IPs must first attend a course to ensure they use these concepts in order to maximize the utility of the flight simulators and the overarching flight-training program. Detailed experiments should intentionally focus on proving or disproving simulators' capability to replace entire training events while utilizing the highest quality intentionally designed course. Further, researchers must analyze the extraneous variables that many senior aviators feel student pilots can only learn in the real aircraft to gain full training effects.

One potential strategy that researchers should study utilizes proficiency-based training, which provides students the opportunity to progress according to their skill level and ability to

learn tasks, rather than the currently prescribed time based training, geared for the slowest learning pilots.[193] Currently, every pilot flies the same number of hours regardless of when they achieved proficiency. If using increased simulator training within a proficiency based training program, students who require more hours than the fastest student could train the number of repetitions required in a relatively short time period to achieve the standard, thus allowing for students to finish FSXXI in a shorter time period with valuable resources saved.

Additionally, FSXXI could potentially decrease risk by maintaining some use of the TH-67 aircraft. Further research could show improved economic value and increased student performance by training and practicing the individual tasks in the simulator, then moving to the real TH-67 to validate the training through a successive series of check rides at specific intervals in the program.[194] This could evolve into either the optimal solution or part of a scalable solution.

Experiments should put FSXXI students through purely simulation-based programs and compare them to standard FSXXI students upon completion of training. Instructors should then identify whether the simulator test-students possess decreased proficiency (increased risk) due to not having exposure to the real aircraft until basic combat skills, or if students can overcome the primacy issues by flying the real aircraft in later stages of flight school. Only a comprehensive, objective experiment along these lines will resolve the issue. Researchers must study the costs and benefits, seeing that the advanced airframes, used in the later stages of flight school cost more to operate than the TH-67. With regard to using purely simulation in primary and instruments, the Army should develop direct experiments in IERW to generate data on its effectiveness.

Regardless of the changes made in FSXXI with relation to increased simulator usage, studies must follow-up with student pilots as they progress through the advanced stages of FSXXI and graduate to operational units. Analysis must validate their success as they progress to

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[193] Stewart, David M. Johnson, and Howse, "Fidelity Requirements," 3.

[194] Stewart, interview.

RL 1 and become pilots in command. If the test pool successfully validates training, using the updated simulation-based training model, then increased student populations can progress through the program. Additionally, units should record data in order to conduct analysis to see if relationship exists between flight simulator training and aviation accident rates.

With regard to minimizing costs and maximizing benefits, apply future study and analysis to determine the required number of additional simulators and required expansion of Warrior Hall. Study should also determine if this expansion would prove cheaper than continuing to operate real aircraft at current flight hour levels. By increasing simulator training, study should determine the reduced burden on the real aircraft, and the potential for allowing a reset program to take place on the airframes, thus extending their operational life cycle. This could also allow for complete usage within the basic combat skills phase of IERW as the OH-58C life cycle expires. Leaders should conduct second and third order effect analysis. For instance, analysis could determine if surplus TH-67s will exist and if they provide the required capabilities to replace OH-58Cs where used around the operational force, such as at the various Army combat training centers.

Simulators are a reality of the Army training system. Aviation Branch leaders must embrace an intentionally designed program based on empirical data rather than subjective opinion to continue employing the high quality aviators the Army is accustomed to utilizing. Only then will Army Aviation operate within a “cost-culture” that continues to produce the highest quality aviators for the operational force.

APPENDIX

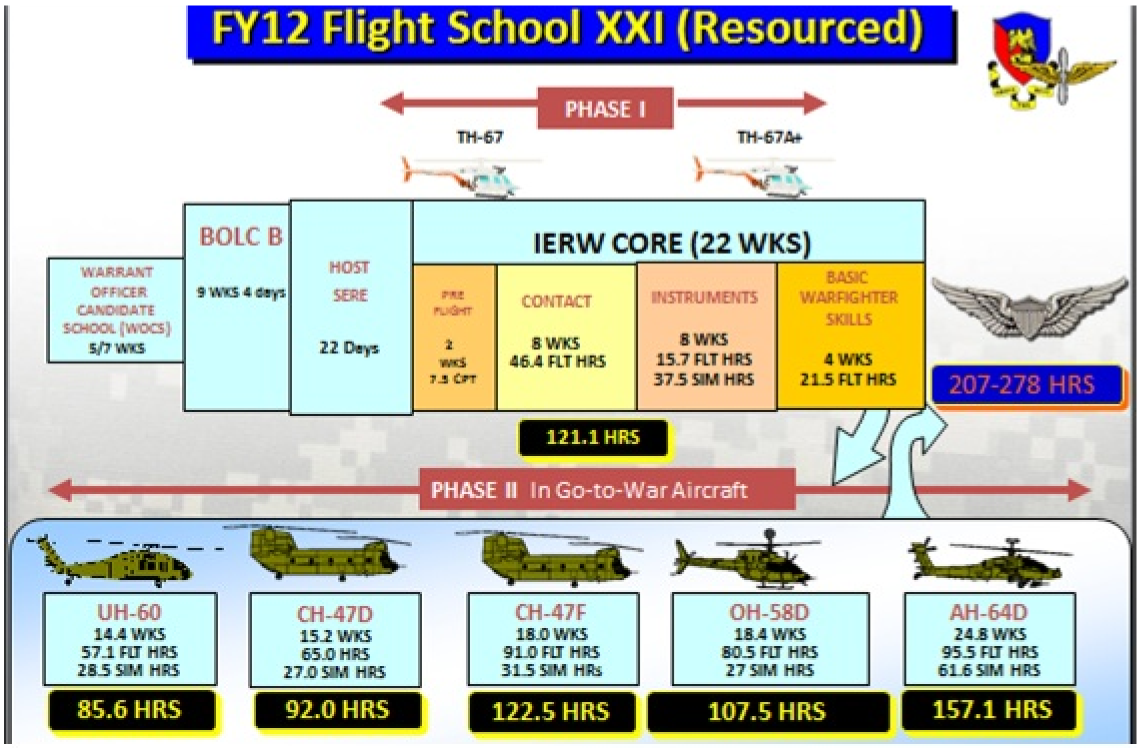

Figure 1: FY 2012 FSXXI Training Program

Source: USAACE, “FY12 FSXXI (Resourced),” (Fort Rucker, AL: USAACE, 2011), 1. This slide depicts the entire FSXXI flight training program. Although instructors teach academic classes each day to flight students, this chart does not depict it—see next two appendices. Also of note in IERW, instructors conduct the pre-flight section in a procedural trainer to train students in aircraft pre-flight and start-up procedures. Students only conduct simulator flight training during the instruments section. Although it appears that students conduct the basic warfighter skills section in the TH-67, students conduct this training in the obsolete OH-58C.

2-3. **TASKS SELECTED FOR TRAINING.**

a. The following tasks and supporting skills and knowledge have been selected for training during this stage of instruction. The daily training requirements may be found in paragraph 2-4.

b. Demonstration (DM). DM will also be used for those tasks that are only demonstrated by the IP and not performed by the student. These tasks will consist of a verbal introduction to the task and a minimum of one demonstration iteration.

c. Familiarization (FM). FM will be used for those tasks that are familiarized and performed by the student, but are not required to be trained or performed to a P3 level. They introduce students to tasks that will be developed in future stages of training. FM tasks will be performed as a minimum of one demonstration iteration and two practice iterations.

d. Performance Tasks are **bolded** with the first letter of each word capitalized and Technical Tasks are sentence case IAW TC 3-04.43

TASK NO	TITLE	PAGE
1000	Participate in a Crew Mission Briefing.	24
1000.01	Perform as a Crewmember (Cockpit Teamwork).	26
1000.02	**Transfer of Flight Controls**	26
1004	Plan a Visual Flight Rules Flight *(FM)*	26
1010	Prepare a Performance Planning Card (PPC).	27
1012	Verify Aircraft Weight and Balance.	32
1014	Operate Aviation Life Support Equipment (ALSE).	35
1022	Perform Preflight Inspection.	35
1024	Perform Before Starting Engine Through Before Leaving Helicopter Checks.	35
1024.01	Perform Hover Check.	36
1024.02	Perform Before-Landing Checks.	37
1024.03	Perform After-Landing Checks.	37
1026	**Maintain Airspace Surveillance.**	38
1028	**Perform Hover Power Check.**	39
1032	Perform Radio Communication Procedures.	39
1038	**Perform Hovering Flight.**	40
1040	**Perform Visual Meteorological Conditions (VMC) Takeoff.**	43
1040.01	**Perform Visual Meteorological Conditions (VMC) Takeoff** (from a hover).	43
1040.02	**Perform Visual Meteorological Conditions (VMC) Takeoff** (from the ground).	43
1040.03	**Perform a Simulated Maximum Performance Takeoff.**	44
1040.04	**Abort a Takeoff While Maintaining Safe Aircraft Control.** *(FM)*	45
1044	**Navigate by Pilotage and Dead Reckoning.** *(FM)*	46
1048	Perform Fuel Management Procedures.	47
1052	**Perform Visual Meteorological Conditions (VMC) Flight Maneuvers.**	48
1052.01	**Perform Acceleration/Decelerations.** *(FM)*	50
1052.02	**Perform Rectangular Course.** *(FM)*	50
1052.03	**Perform "S" Turns.** *(FM)*	52
1052.04	**Perform Climbs and Descents.**	54
1052.05	**Perform Climbing and Descending Turns.**	55
1052.06	**Perform Straight-and-Level Flight.**	56
1052.07	**Perform Turns.**	56
1052.08	**Perform Traffic Pattern Flight.**	57
[redacted]		

Figure 2a: Primary section required tasks

Source: USAACE, "Flight Training Guide: IERW Primary," (Fort Rucker, AL: USAACE, 2011), 8-9. This chart depicts the required tasks each student must successfully learn and execute in the primary section of IERW.

TASK NO	TITLE *(Cont.)*	PAGE
1058.04	**Perform a Shallow Approach to a Run-On Landing.**	62
1058.05	**Perform Approach Termination Procedures.** *(FM)*	63
1062	**Perform Slope Operations.** *(FM)*	63
1070	Respond to Emergencies.	64
1072	**Respond to Engine Failure at a Hover.**	65
1074	**Respond to Engine Failure at Cruise Flight.**	65
1076	**Respond To Hydraulics System Malfunction** *(DM)*	66
1082	**Perform Autorotation.**	67
1321	**Perform Anti-Torque Malfunction.** *(FM)*	69
1323	**Perform Hovering Autorotation.**	70
1327	**Perform Low-Level Autorotation.** *(FM)*	71
1335	**Perform Autorotation With Turn.** *(DM)*	72
3011	Oral Knowledge.	73

Figure 2b: Primary section required tasks

Source: USAACE, “Flight Training Guide: IERW Primary,” (Fort Rucker, AL: USAACE, 2011), 8-9. This chart depicts the required tasks each student must successfully learn and execute in the primary section of IERW.

2-3. TASKS SELECTED FOR TRAINING.

a. The following tasks and supporting skills and knowledge have been selected for training during this stage of instruction. The daily training requirements may be found in paragraph 2-4.

b. Performance Tasks are **bolded** with the first letter of each word capitalized and Technical Tasks are sentence IAW TC 3-04.43.

TASK CHART (STAGE I)

TASK#	TASK	PAGE
1182	**Perform Unusual Attitude Recovery.**	48
3001	**Perform Instrument Maneuvers.**	49
3001.01	**Perform Straight-and-Level Flight.**	49
3001.02	**Perform Climbs and Descents**	49
3001.03	**Standard Rate Turn**	49
3001.04	**Steep Turn.**	49
3001.05	**Climbing and Descending Turn.**	49
3001.06	**Perform Acceleration/Deceleration.**	49
3001.08	Perform Instrument Cross Check	53

TASK#	TASK (Cont)	PAGE
3001.09	Perform Instrument Interpretation.	53
3001.10	Perform Trim Control.	54
3001.11	Perform Flight Fundamentals.	54
3001.12	Use of Force Trim.	54

Figure 3a: Instrument section tasks selected for training, Stage I

Source: USAACE, “Flight Training Guide: Instrument,” (Fort Rucker, AL: USAACE, 2011), 7. This chart depicts the required tasks each student must successfully learn and execute in the first stage of the instrument section of IERW.

TASK CHART (STAGE II)

TASK#	TASK	PAGE
1000	Participate in a Crew Mission Briefing.	21
1000.01	Perform as a Crewmember (Cockpit Teamwork).	24
1006	Plan an IFR Flight.	24
1010	Prepare a Performance Planning Card (PPC).	25
1012	Verify Aircraft Weight and Balance	30
1014	Operate Aviation Life Support Equipment (ALSE)	33
*1022	Perform Preflight Inspection. (Student Assist)	33
1024	Perform Before-Starting Engine Through Before-Leaving Helicopter Checks.	34
1024.01	**Perform Hover Check.**	35
1028	**Perform Hover Power Check.**	35
1032	Perform Radio Communications Procedures.	36
1032.01	Perform Procedures for Two-Way Radio Failure (Oral).	37
1048	**Perform Fuel Management Procedures.**	37
1070	Respond to Emergencies.	38
1170	**Perform Instrument Takeoff (ITO).**	39
1172	**Perform Radio Navigation.**	40
1174	**Perform Holding Procedures.**	41
1174.01	**Perform Holding Procedures** (VOR).	41
1174.02	**Perform Holding Procedures (LOC).**	41
1174.03	**Perform Holding Procedures** (GPS).	41
1176	**Perform Non-Precision Approach.**	42
1176.01	**Perform Non-Precision Approach** (VOR).	42
1176.02	**Perform Non-Precision Approach** (LOC).	42
1176.03	**Perform Non-Precision Approach** (GPS).	42
1176.04	**Perform Non-Precision Approach** (ASR).	42
1178	**Perform Precision Approach.**	44
1178.01	**Perform Precision Approach** (ILS).	44
1178.02	**Perform Precision Approach** (GPS/LPV).	44
1178.03	**Perform Precision Approach** (PAR).	44
1184	**Respond to Inadvertent Instrument Meteorological Conditions**	48
3001.07	**Perform Missed Approach.**	52
3001.08	Perform Instrument Cross Check.	53
3001.09	Perform Instrument Interpretation.	53
3001.10	Perform Trim Control.	53
3001.11	Perform Flight Fundamentals.	54
3001.12	Use of Force Trim.	54
3011	Oral Knowledge	55
3012	Scenario Training (Training Days 72 and 73)	55

*__NOTE__: SP should assist the IP in daily A/C preflight inspection requirements. Proficiency in this TH-67 task is **not required** to be demonstrated as part of this training program.

Figure 3b: Instrument section tasks selected for training, Stage II

Source: USAACE, “Flight Training Guide: Instrument,” (Fort Rucker, AL: USAACE, 2011), 8. This chart depicts the required tasks each student must successfully learn and execute in the second stage of the instrument section of IERW.

CHAPTER 2. TRAINING SEQUENCE

2-1. **FLIGHT HOURS.**

a. The primary stage of training is broken down as follows:

TH-67	EVALS	TOTAL
44.4	2.0	46.4

b. Flying time:

(1) Aircraft: Training flights – 1.2 hours per day
P1 Evaluation flight – 1.0 hour
P2 Evaluation flight – 1.0 hour

(2) A total of 45.4 hours must be completed prior to the P2 evaluation.

OBJECTIVE FLIGHT HOUR CHART

PRE-FLIGHT STAGE										
TNG DAY	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Academics	----------Aeromedical----------					ACT-B	----------TH-67 Systems----------			
CPT							1.5	1.5	1.5	1.5

PRIMARY STAGE I (P1)										
TNG DAY	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
FLT PD	1	2	3	4	5	6	7	8	9	10
Academics	----------TH-67 Systems----------					----------Flight Support Subjects----------				
CPT	1.5									
TH-67	PRE-Flight	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
CUMUL		**1.2**	**2.4**	**3.6**	**4.8**	**6.0**	**7.2**	**8.4**	**9.6**	**10.8**

								EVAL
TNG DAY	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**
FLT PD	11	12	13	14	15	16	17	18
Academics	----------Theory of RW Flight----------					----------Navigation----------		
TH-67	1.2	1.2	1.2	1.2	1.2	1.2	1.2	**1.0**
CUMUL	**12.0**	**13.2**	**14.4**	**15.6**	**16.8**	**18.0**	**19.2**	**20.2**
								(0795)

PRIMARY STAGE II (P2)											
TNG DAY	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**
FLT PD	19	20	21	22	23	24	25	26	27	28	29
Academics	----------Navigation----------							----------Weather----------			
TH-67	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
CUMUL	**21.4**	**22.6**	**23.8**	**25**	**26.2**	**27.4**	**28.6**	**29.8**	**31.0**	**32.2**	**33.4**

											EVAL
TNG DAY	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**
FLT PD	30	31	32	33	34	35	36	37	38	39	40
Academics	----------Weather----------					----------Instrument Orientation----------					
TH-67	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	**1.0**
CUMUL	**34.6**	**35.8**	**37.0**	**38.2**	**39.4**	**40.6**	**41.8**	**43.0**	**44.2**	**45.4**	**46.4**

Figure 4: Primary Flight Training Sequence

Source: USAACE, “Flight Training Guide: IERW Primary,” (Fort Rucker, AL: USAACE, 2011), 6. This chart depicts the objective flight hours and academic training programmed for instruction for each student in the primary section of IERW.

CHAPTER 2. TRAINING SEQUENCE

2-1. FLIGHT HOURS.

This instrument stage of training consists of 53.2 dual flight training hours (37.5hours in the TH-67 HFS and 15.7 hours in the TH-67 helicopter) which are broken down as follows:

TNG STAGE	HFS	TH-67	TOTAL
Stage I	10.5	0.0	**10.5**
Stage II	27.0	15.7	**42.7**
TOTAL	**37.5**	**15.7**	**53.2**

OBJECTIVE FLIGHT HOUR CHART

STAGE I								
TNG DAY	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**
FLT PD	1	2	3	4	5	6	7	8**
Academics	DOD FLIP	RMI	RMI	RMI/PE1	Exam I	Radio Nav	Holding	Appr. Proc
HFS*	1.5	1.5	1.5	1.5	1.5	1.5	1.5	0.8E
CUM TIME	**1.5**	**3.0**	**4.5**	**6.0**	**7.5**	**9.0**	**10.5**	**11.3**

STAGE II								
TNG DAY	**58**	**59**	**60**	**61**	**62**	**63**	**64**	**65**
FLT PD	1**	2	3	4	5	6	7	8
Academics	Approach Procedures			PE2	Exam II	Gen Flight Rules	ATC / IFR Commo	IFR Commo
HFS*	0.7	1.5	1.5	1.5	1.5	1.5	1.5	1.5
CUM TIME	**12.0**	**13.5**	**15.0**	**16.5**	**18.0**	**19.5**	**21.0**	**22.5**

TNG DAY	**66**	**67**	**68**	**69**	**70**	**71*** **	**72*** **	**73*** **
FLT PD	9	10	11	12	13	14	15	16
Academics	IFR Commo	PE3	Exam III	IFR FLT Plan				PE4
HFS*	1.5	1.5	1.5	1.5	1.5			
OFT						1.5	1.5	1.5
CUM TIME	**24.0**	**25.5**	**27.0**	**28.5**	**30.0**	**31.5**	**33.0**	**34.5**

TNG DAY	**74*** **	**75*** **	**76*** **	**77*** **	**78*** **	**79*** **	**80*** **	**81**
FLT PD	17	18	19	20	21	22	23	24
Academics	Exam IV	Critique	ACT-E Initial Qualification		ACT-E Exam	Terrain Flt Operations (TFO)		TFO Exam
OFT	1.5	1.5						
TH-67			1.1	1.1	1.1	1.1	1.1	1.0
CUM TIME	**36.0**	**37.5**	**38.6**	**39.7**	**40.8**	**41.9**	**43.0**	**44.0**

TNG DAY	**82**	**83**	**84**	**85**	**86**	**87**	**88**	**89**	**90**
FLT PD	25	26	27	28	29	30	31	32	33****
Academics	Map Prep Brief								
TH-67	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.2E
CUM TIME	**45.0**	**46.0**	**47.0**	**48.0**	**49.0**	**50.0**	**51.0**	**52.0**	**53.2**

*HFS = Instrument Flight Trainer (IFT) or Operational Flight Trainer (OFT)

**FLT PD 8/ FLT PD 1 are scheduled as a guide for the STAGE I evaluation (0.8 hours) and STAGE II Training (0.7 hours).

***Training during TD-71 thru TD-80 must be conducted for all students; however, it may be scheduled as necessary within the 10 training days to level out resource requirements for simulator and aircraft usage.

****FLT PD 33 is scheduled for the STAGE II evaluation.

Figure 5: Instruments section training sequence

Source: USAACE, "Flight Training Guide: IERW Instrument," (Fort Rucker, AL: USAACE, 2011), 6. This chart depicts the objective flight hours and academic training programmed for instruction for each student in the instrument section of IERW.

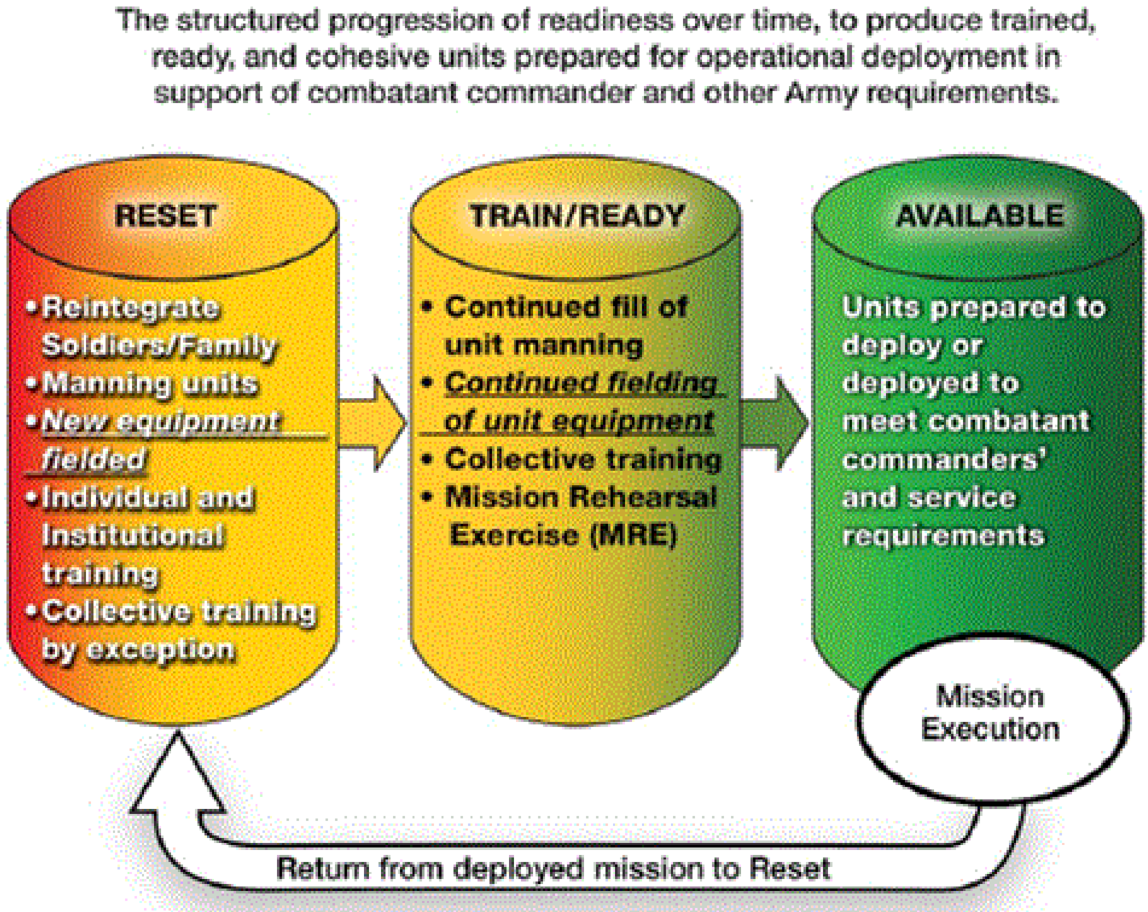

Figure 6, ARFORGEN phases and tasks

Source: U.S. Army, *AR 525-29: Army Force Generation* (Washington, D.C.: Department of the Army, 2011), 5. This chart depicts the three phases of ARFORGEN, along with the individual and collective responsibilities within each phase.

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